INDIAN METEOROLOGICAL MEMOIRS.

I.—On the winds of Calcutta. An analysis of ten years' hourly observations of the wind vane and four years' anemograms. By HENRY F. BLANFORD, F.G.S., *Meteorological Reporter to the Government of India.*

IN the following pages I have attempted an analysis of the regular annual and diurnal variation of the winds that blow at Calcutta. In some respects this work may be regarded as a further development of that described in my paper on the winds of Northern India, published in the 164th volume of the Philosophical Transactions;* being, in fact, a detailed investigation of the winds of a single station, included in the system therein treated of from a general point of view; and the general conclusions then drawn from a review of the meteorology of the country at large, will find their application, and at the same time their partial verification and explanation, in the more limited but more detailed enquiry which is the subject of the present memoir. For a thorough analysis of the wind system of any given station has more than a merely local interest. It will generally be found that such a system is made up of many distinct elements, some of greater, others of less, local importance; and it not infrequently happens that when these are separated and subjected to independent study, they furnish a key to the explanation of much that is foreign to the place itself, and may even help to throw light on some of the higher generalizations of the science.

Such, I venture to think, has been one result of the present investigation. It has, in the first place, confirmed Mr. F. Chambers' interesting discovery† of the existence of a semi-diurnal variation of the wind direction, which appears to have a definite relation to the semi-diurnal oscillations of barometric pressure, the so-called barometric tides; and it has brought to light the existence of two very distinct elements in the diurnal wind-variation of single period, which fact, taken in conjunction with certain others previously established in this and other countries, has led me to distinguish and define a class of winds or wind components which I have termed winds of elastic expansion. These co-exist with the well-known convection currents, explained by Hadley's theory; which latter are doubtless more important and include all the greater movements of the atmosphere. But as a physical phenomenon these former are distinct, and depend on a different set of conditions, which I shall endeavour to define and explain in a separate paper.

* Part 2, pages 563 to 653.

† The fact that the pressure of the wind is subject to a semi-diurnal oscillation which is coincident with the barometric tides was discussed by M. Kreil in January 1861. (Sitzungsber. Wiener Akad. xliii, 2nd Abth. p. 121.) I believe Mr. Chambers was not aware of this when he prepared his paper.

The present paper consists of two parts: the first gives an analytical description of the winds that prevail at Calcutta at different seasons of the year, and the variation they tend to undergo daily, both in velocity and direction. In the second is discussed the local relations of wind direction to temperature, pressure, and rainfall; the data having been reduced to the form of wind-roses and corrected by Bessel's formula. In this part of the discussion, certain relations have been established between the wind direction and the frequency of rainfall, which may hereafter become of importance in assisting a judgment of the probability of rain.

The formulæ of interpolation and other mathematical reductions have been computed partly by myself, but chiefly by Babu Brojomohun Rakhit, Chief Computer of the Meteorological Office.

PART I.

Annual and Diurnal Variation of the Winds.—The data which have furnished the materials of the following description are—

A.—Ten years' observations of the wind vane, recorded hourly (to 8 points of the compass) together with the occurrence (not the quantity) of rain, at the hours of observation. These extend from August 1856 to July 1866.

B.—Four years' registers of a Secchi's anemograph recording the movement of the wind in each half-hour. These extend from July 1871 to June 1875.*

C.—Fifteen months' registers of a Beckley's anemograph extending from January 1874 to March 1875.

The first series were recorded at the Surveyor-General's Office in Park Street, Calcutta; the second at St. Xavier's College, also in Park Street, and facing the former building, from which it is about 80 yards distant to the south. Both buildings are lofty and range well above any others in the neighbourhood; the anemometer at the Surveyor-General's Office is 72 feet above the ground, that on St. Xavier's 57 feet. The former building being some few feet higher than the latter, it is probable that it obstructs to some extent the free action of north winds on the College anemometer. But this effect is certainly small in comparison with that of friction, which in this instrument is evidently very high, but which cannot be corrected, the requisite co-efficients never having been experimentally determined.

The third series are the results of a Beckley's anemograph erected on the Meteorological Office in Chowringhee Road, nearly a mile to the north-west of the two former buildings. At present only 15 months' registers have been obtained from it, and even these are not an unbroken series. I have, therefore, used them only for the purpose of instituting a general comparison with the results of the Secchi instrument; and the

* For these I am indebted to the kindness of the Reverend E. Lafont, S.J., the principal of the St. Xavier's College. The trace has been measured off and tabulated by Babu Khettra Mohun Ghosh, draughtsman of the Meteorological Office.

latter alone have been subjected to a detailed analysis, with a view to determining the annual and diurnal variation of the air movement.*

The Secchi anemometer is driven by the usual cup and ball sails, devised by Dr. Robinson. The revolving frame bears four cups, each of 5¼ inches diameter, and measures 1 foot 6 inches from the centre of the axis to the centre of each cup. The distance travelled is recorded, for half-hour intervals, on such a scale, that a line 5 millemeters in length indicates one kilometer of the wind's movement. In tabulating the trace, kilometers have been reduced to miles by multiplying by the factor 0·62. Direction is recorded to eight points of the compass.

I have already stated that the friction error of the instrument is very large. In every month of the year the total movement recorded by it is below that registered by the little dial anemometer on the Surveyor-General's Office opposite, and still more in defect of that shewn by the Beckley on the Meteorological Office. In May, when the average daily movement recorded by the latter instrument was 286 miles, the former gave an average of 275 miles, or a deficiency of 1-26th only. But in December, when the Beckley registered an average of 112 miles, the Secchi recorded only 53 miles, or less than one-half.

The following table shews in parallel columns the average diurnal movement recorded by each of the three instruments.

TABLE I.—Comparative table of the average daily movement of the wind as recorded by different instruments.

Month.	4 Years.		15 Months.		
	Secchi.	Adie.	Secchi.	Beckley.	Difference.
January	58·35	80·1	61·8	111·2	46·4
February	77·73	85·0	78·1	119·0	40·9
March	121·80	130·8	117·4	164·6	47·2
April	187·12	189·1	207·3	218·2	10·9
May	194·42	197·4	274·7	285·7	11·0
June	167·40	184·7	151·0	179·9	28·9
July	131·74	143·3	146·3	171·9	25·6
August	108·58	120 4	108·5	143·0	34·5
September	107·15	115·1	92·0	122 5	30·5
October	78·40	98·2	90·7	144·1	53·4
November	57·78	86·0	75·9	128 3	52·4
December	49·11	89·3	52·9	112·0	59·1

I have not attempted to apply any empirical correction to the Secchi registers. But it must be borne in mind that the wind movement shewn by them is very considerably below the truth, more especially from October to March.

In the paper on the winds of Northern India already referred to, I gave a brief description of the annual variation of the wind at Calcutta, as deduced from the hourly

* The position of this instrument is not free from objection. The house is indeed one of the loftiest in the Chowringhee Road and to the west is the open maidan. But less than 100 yards to the south, is the new Museum building, a gigantic block which dominates it by 20 feet.

observations recorded during 10 years at the Surveyor-General's Office. In the table which accompanied the description, the mean direction of the wind was deduced from simple observations of the wind vane by means of Lambert's formula; an equal value being assigned to all observations, without regard to variation of velocity. In their main features, the results now obtained from the Secchi anemograms, in which the variation of velocity is duly regarded, accord fairly with the above, as may be seen in the following comparative table; but the coincidence is not exact in all particulars; and some apparent irregularities which were noticed in the results of direction only, tend to disappear when regard is had to the variation of velocity in the different azimuths. In the following table the first two columns are a reproduction of the former results, and shew the mean direction of the wind in each month, deduced in the manner above described, together with the excess in that direction shewn as a percentage of the *number of observations.* The next pair of columns give the mean direction and excess percentage, obtained by the like process from the direction observations of the four years to which the Secchi anemograms relate. The third pair of columns shew the mean direction and the percentage of total *movement* in that direction during these four years (July 1871 to June 1875) deduced from the Secchi anemograms; and the five remaining columns, the total average diurnal movement in miles, and the diurnal excess in the directions north and south, or east and west, and that of their resultant obtained from the same data. North and east components are denoted by + and south and west by — signs.

TABLE II.—Annual variation of the wind at Calcutta, deduced from observations of direction and the registers of a Secchi anemograph.

MONTH.	10 YEARS' OBSERVATIONS.		4 YEARS' OBSERVATIONS		4 YEARS' SECCHI ANEMOGRAMS.						
	Per cent. observations.	Mean direction.	Per cent. observations.	Mean direction.	Per cent. movement.	Mean direction.	Total daily movement in miles.	North comp. miles per day.	East comp. miles per day.	Resultant. Miles.	Resultant. Direction.
January ...	40	N 38°W	21	N 17°W	24	N 27°W	58·35	+ 12·66	— 6·39	14·18	N 27°W
February ...	23	S 79 W	28	N 82 W	22	N 88 W	77·73	+ 0·68	—17·32	17·33	N 88 W
March ...	47	S 33 W	66	S 29 W	63	S 25 W	121·80	— 69·84	—32·88	77·19	S 25 W
April ...	74	S 3 W	80	S 6 W	74	S 8 W	187·12	—136·91	—19·13	138·24	S 8 W
May ...	65	S 12 E	71	S 6 W	66	S 15 W	194·42	—122·59	—33·50	128·22	S 15 W
June ...	58	S 5 E	66	S 2 E	59	S 14 E	167·40	— 96·06	+23·98	99·00	S 14 E
July ...	65	S 12 E	66	S 14 E	52	S 26 E	134·74	— 63·66	+30·72	70·68	S 26 E
August ...	55	S 18 E	65	S 16 E	53	S 53 E	108·58	— 35 06	+45·88	57·81	S 53 E
September ...	40	S 30 E	60	S 17 E	51	S 37 E	107·15	— 42·97	+32·86	54·09	S 37 E
October ...	13	N 53 W	12	N 86 E	48	N 42 E	78·40	+ 27·62	+25·46	37·56	N 42 E
November ...	58	N 19 W	47	N 27 W	72	N 1 E	57·78	+ 41·41	+ 0·62	41·41	N 1 E
December ...	60	N 27 W	62	N 36 W	77	N 3 W	49·11	+ 37·90	— 2·19	37·96	N 3 W
Year ...	21	S 14 W	29	S 12 W	35	S 18 E	111·89	— 37·23	+12·03	39·12	S 18 E

This table shews that, on the average of the year, there is a large excess of air movement from the south, and a smaller but still considerable excess from the east; the resultant direction being approximately south-south-east, and the residual movement from that direction amounting to 39 miles per day. This differs from the result formerly obtained from the simple observations of direction (without regard to velocity), inasmuch as this latter method shewed an excess of movement from the west, in consequence of westerly elements being more frequent. It also differs in the same way and for the same reason from the result of the same four years 1871-75, when the direction obser-

vations only are treated by Lambert's formula. Comparing the two results, it appears that southerly wind elements are not only more frequent, but also have a higher average velocity than northerly elements;* and that easterly elements, while less frequent than westerly, are stronger than the latter in a more than compensating ratio. The resultant direction S. 18° E. is almost identical with that which prevails in the months of June and July; that is to say, the first half of the south-west monsoon; and goes far to confirm the conclusion which I formerly drew, *viz.*, that the south-west or summer monsoon is superior in steadiness and velocity to the north-east or winter monsoon. According to the present table, the net uncompensated transfer of air from the direction S. 18° E. to N. 18° W., over the city of Calcutta, amounts to 14,280 miles in the course of the year. Probably, as pointed out in the note on the previous page, it is really somewhat less than this.

It appears, from data furnished by Mr. Charles Chambers, that at Bombay, the uncompensated motion of the air towards the land, in one year, was four and a half times as great as the above, *viz.*, 61,904 miles, and in the direction N. 70° W.—S. 70° E. These differences are only such as might be expected from the very different positions of the two stations, on opposite sides of the peninsula,—the one, moreover, being on the coast line, the other a considerable distance inland. But even as compared with the total movement (387 miles daily), the uncompensated movement is proportionally higher at Bombay, *viz.*, 44 per cent. against 35 per cent. at Calcutta; and even at Saugor Point, at the mouth of the Hooghly estuary, the total movement is much below that of Bombay, *viz.*, 229 miles as against 387 miles *per diem*. I think it, therefore, highly probable that the air pours into the western side of the Peninsula in much greater volume than from the eastern coast. Such an inference might be drawn independently from the facts adduced in my paper already referred to, which tended to shew that the monsoon from the west coast prevails over a much larger area of the interior than that which proceeds from the Bay of Bengal; and that the movement of the winds at inland stations, such as Nagpore, within the influence of the Arabian Sea branch of the monsoon, is much higher than at those in the Gangetic plain, which is comprehended in the eastern wind system.

The resulting direction of the wind at Bombay being about from west-north-west, while that of Calcutta is from south-south-east, implies a tendency of the air currents to form a cyclonic circuit around the Peninsula; or rather an influx of spiral currents. The opposite tendency during the cold weather months, when India is an anti-cyclonic area, is much weaker; and the excess of centripetal currents in the lower atmosphere must therefore be compensated by an equivalent excess of centrifugal currents in its higher regions.

The table further shews that, excepting during the south-west monsoon, when the movement is proportionally higher than the temperature of that season, the total movement of the air varies directly as the temperature, being greatest in May, least in

* It is not improbable that the apparent excess of southerly elements is somewhat exaggerated in the table, owing partly to the obstruction of the neighbouring building noticed above, in the text (page 2), and partly to the high friction of the instrument; since these both reduce the recorded velocity, chiefly in those months in which northerly elements predominate. But east and west elements would be less affected; and even in the former case the exaggeration is probably not very great.

December; but the steadiness of the wind's direction by no means follows the same law, since this is greatest in December, and least in January and February. The annual curves of wind velocity and temperature are given on Plate I, Figs. 2 and 3.

The annual rotation of the wind direction at Calcutta is shown by Table II and also by Plate I, Fig. 1, to be completely retrograde (not incompletely, as was inferred from the discussion of observed directions only). In November and December the average direction is almost due north, and very steady; the resultant movement on the average of the two months being 75 per cent. of that in all azimuths. In January and February the winds work round to north-west and west; but while their total movement is greater in those months than in the two former, it is no longer steady from the same quarter, falling from an average of 75 to one of 23 per cent. of the whole in the direction of the resultant. This is a very striking fact, since at sea, to the southward, the north-east monsoon is at its height in those months. The explanation is by no means obvious. It is evident from the Table C (Appendix) and diagrams (Plates III, IV) of the diurnal variation of the winds, that in November and December, the east and west oscillation, which becomes so marked in the hot-weather months, is very small; and that the principal variation in the regular movement of the air consists in the varying strength of the wind which blows towards the estuary of the Hooghly: it is strongest about midday, and sinks to a minimum an hour or two after sunset. This wind coincides in direction with the local diurnal land breeze, but it is more steady in November and December than in January, while in February it altogether fails, although the difference of the mean temperatures of the land and sea, the presumed cause of such a wind, is greater in the first two months of the year than in November and December. Beyond the fact that in the last two months of the year the temperature is generally falling, whereas in the first two months it is rising,—and thus, as will hereafter be shewn, tending to set in motion the westerly land winds of the interior,—the only circumstance that I can discover in the temperature phenomena which may possibly help to explain the apparent anomaly, is that, as compared with the difference of the mean temperatures of land and sea, the difference in the diurnal range over the two surfaces is considerably less in November and December than in the two following months. On comparing the mean temperature at Jessore* with that at Saugor Island, I find that the differences

* Jessore is a better station for such a comparison than Calcutta, where the observatory is so situated that the recorded temperatures must be much affected by the buildings around.

The day and night temperatures, here contrasted, are not the maximum and minimum temperatures, but the means of the temperatures observed at 10 A.M. and 4 P.M. for the day, and those of 10 P.M. and 4 A.M. for the night. The following is a tabular statement of the data from which the ratios given in the text are deduced:—

Month	Jessore.			Saugor Island.			Difference of ranges.	Mean temperature.			Ratio D. M. to D. R.
	Day.	Night.	Mean range.	Day.	Night.	Mean range.		Jessore.	Saugor Island.	Difference.	
November	80·1	65·6	14·5	79·4	70·8	8·6	5·9	72·8	75·0	2·2	37 : 100
December	74·2	56·7	17·5	73·2	63·8	9·4	8·1	65·4	68·5	3·1	38 : 100
January	74·8	56·5	18·3	72·7	64·2	8·5	9·8	65·6	68·4	2·8	28 : 100
February	80·8	62·4	18·4	77·7	71·3	6·4	12·0	71·6	74·5	2·9	24 : 100

of these mean temperatures bear the following ratios to the differences of their respective ranges in the four cold-weather months:—

November	...	...	...	...	37 to 100
December	...	...	...	...	38 „ 100
January	...	...	...	...	28 „ 100
February	...	...	...	...	24 „ 100

In November and December, the mean day temperature (see footnote page 6) of the land, as represented by Jessore, is only 0·7° to 1·0° higher than that of the sea, as represented by Saugor Island. In January and February, however, the increasing range over the land brings up the day temperature to from 2·1° to 3·1° higher than that of the sea, and the tendency to reverse the direction of the wind, which eventually results from such a rise, may be one cause of the unsteadiness of the land breeze in January and February. Whatever be the cause, the northerly or local land wind, as a predominant component of the system, becomes insignificant in January and disappears in February; while the westerly or rather west-north-west wind, the land wind of Upper India, gains in importance.

In March, April, and May the increasing temperature of the delta produces a strong steady current from the sea, and the predominant direction is almost diametrically opposite to that which prevailed in November and December. The wind now blows mainly from the direction of the Hooghly estuary, or somewhat more westerly, owing evidently to the influence of the westerly land winds from the interior.

In June, the rainy monsoon sets in with a shift to the east of south; the westerly land wind having disappeared, as the clouds accumulate over the interior of the country and the pressure falls. In the latter part of that month, in July, August and September, the prevalent direction is that of a current setting towards the Upper Provinces. It is very different from that which prevails in the hot-weather months, when the winds from the sea are comparatively local, but at the same time more steady, and blow with greater force. The mean direction of June is intermediate between the two; since the monsoon, as a rule, does not set in till the middle of the month, and the winds of the earlier part are such as are characteristic of May.

In October, the general course of the winds tends to be cyclonic around the Bay of Bengal; and at Calcutta, the average movement is from the north-east. But this tendency is shewn as a resultant of the actual movement, chiefly in consequence of the greater strength of the winds that blow from that quarter. On the mean of the observed directions during ten years, westerly winds are, numerically, slightly in excess.

It follows from the above, that the annual retrograde rotation of the Calcutta winds is a consequence of the successive prevalence of four currents; two of which depend on local conditions, and two on those which prevail over the interior of the country. The northerly land wind of November and December, which is comparatively of local origin, is followed by the westerly land wind from the interior, which, as will afterwards be shewn, is essentially a day wind. This determines the direction of

the resultant in January and February; and in March, April, and May it manifests itself chiefly by giving a somewhat westerly bias to the strong wind that blows from the Hooghly estuary and the sea, directly towards the heated delta. During the hot-weather months, this undergoes but little change of direction; but, as soon as the south-west monsoon is established, the great local contrast of temperature that characterises the hot-weather months is in a measure obliterated; and a current from the Bay of Bengal (proceeding originally from the ocean to the south) blows from the south-east, over Calcutta, towards the Gangetic plain and the hilly country to the west of the delta. As this yields place in October to the returning local land wind, it becomes more northerly; and in November the latter wind is re-established.

The Tables in the Appendix give in full detail the data on which this description is based; and Plate I, Fig. 1, and Plates III, IV, shew the principal results in a graphic form.

Although the annual, and, as will presently appear, the normal diurnal rotation of the wind, in most months, is retrograde, when regarded *per se*, still the actual movement of the wind vane is more frequently direct than retrograde. The self-registered trace of the Beckley's anemometer on the Meteorological Office shews that in fifteen months, from January 1874 to March 1875, there were 34 complete revolutions of the vane in the order south, west, north, east, and only nine in the opposite direction. These were distributed in the several months as follows:—

	Dir.	Ret.		Dir.	Ret.
January 1874 ...	8	3	September 1874 ...	1	0
February " ...	4	2	October " ...	5	0
March " ...	5	2	November " ...	1	0
April " ...	0	0	December " ...	0	0
May " ...	2	0	January 1875 ...	2	1
June " ...	0	0	February " ...	2	0
July " ...	2	0	March " ...	1	0
August " ...	1	1			

Table A (Appendix) shews the average velocity of the wind, hour by hour, in each month of the year; and also the mean of all the months, giving what may be regarded as the mean diurnal variation of velocity. This last is represented graphically in Plate II, Fig. 3. As in the case of the mean annual variation, the general form of the curve closely resembles that of the temperature (Fig. 4), and such is also the case in each of the months individually (Plate V), with the partial exception of March, in which month the rapidity of the wind's movement is maintained, almost unabated, until after 10 P.M. The velocity of the movement is least about half-past 5 A.M., or half an hour before sunrise, increases very rapidly up to half-past 9, and then less rapidly till after 11 A.M. Between half-past 11 and half-past 12 it suffers a check, but subsequently increases further up to half-past 2 P.M. After this it declines very rapidly between 4 and 7 P.M., and more slowly and steadily afterwards. The somewhat anomalous interruption in the regularity of the curve about noon, which is so noticeable in the figure, appears in the

curve of most months, and is much exaggerated in those of April, May and September, and wanting only in February. In June it occurs an hour earlier and in December an hour later than the average. It coincides on an average with that tendency of the wind to shift to the north-west which, as is shewn in Plate I, Figs. 4 and 5, occurs after the morning maximum of pressure; and since the average resultant movement of the wind has been shewn to be from nearly the opposite quarter, this might perhaps be urged in explanation, were it not that it is somewhat more marked in the curve for January, when the average direction of the wind is north-west, than in the mean curve of the year; while in July, when the wind is about south-south-east, it is scarcely perceptible. It will be of interest to ascertain whether the velocity curves of other stations and those recorded by other instruments in Calcutta shew a similar feature.* At present I am unable to suggest any probable explanation of the apparent phenomenon.

I now pass to the consideration of the mean diurnal variation in the direction as well as the velocity of the wind, the data for which are given in tables B, C, and D. (Appendix). The first shews the number of winds observed under each octant of the compass, at each hour of the day, for each month separately, during 10 years; the second the average residual movement of the wind during each hour of the day, in each month, after eliminating all conflicting movements, as shewn by the registers of the Secchi anemograph, for four years; and table D the same movement on the average of the year,—first, as obtained from the observations, and second, as corrected by Bessel's formula computed to four periodical terms. The curve, Plate I, Fig. 4, is such, that a line drawn from any point on the curve to the point A, would represent in length and direction the differential movement of the wind during the hour preceding that which is designated by the figure opposite to it; the difference, that is to say, between the direction and velocity of the wind in that hour, and in an equal period on the average of the 24 hours throughout the whole year. Such lines will represent the hourly movement of the air under the influence of diurnal causes only, and on the supposition that each particle of air at the end of each 24 hours occupies the same place as at the beginning. This is the most convenient form in which to study the results.

In a paper published in the 163rd volume of Philosophical Transactions of the Royal Society, Mr. F. Chambers drew attention to a double period, or semi-diurnal variation of the wind at Bombay, coinciding apparently with the double diurnal oscillation of the barometer. Representing the whole diurnal variation of the wind by a curve similar in principle to that given in Fig. 4, he shewed that, if points be marked off on it corresponding to the instants of highest and lowest barometric tide, they fall approximately in a right line, which line includes also the central point A of the curve. This line,

* In order to make sure that the interruption is not attributable to something in the manipulation of the instrument, such as, *e. g.*, the loss of a part of the record while the recording sheet is removed and replaced, I made enquiry of M. Lafont respecting his practice in this matter. He informs me that the paper is changed once a week only, *viz.*, 5 minutes before noon, and the process occupies four or five minutes. Now, on the mean of the year, the wind's movement between half-past 11 and half-past 12 is about 0·17 mile less than that which would give an unbroken wind curve, or about $\frac{1}{17}$ of the, in that case, total movement. But a loss of 5 minutes' record once a week would amount to $\frac{5}{60}\times\frac{1}{7}=\frac{1}{84}$ only; and even were it sufficient to account for the phenomenon, it would leave unexplained the great inequality of the amount in different months of the year.

which is the major axis of the curve, was found moreover to coincide in direction with the land and sea breeze; and Mr. Chambers pointed out that the diurnal variation might be considered as made up of the alternation of the land and sea breezes, combined with the double diurnal variation above referred to. On resolving this double oscillation into its meridianal (north and south) and longitudinal (east and west) components, Mr. Chambers found that the former are at their maximum positive and negative values, or, in other words, the wind is alternately most northerly or most southerly, midway between the times of the barometric maxima and minima, *viz.*, southerly during the fall, and northerly during the rise; whereas the latter reach their maximum values approximately at the times of greatest and least pressure. The tendency of the wind is from the east at the time of maximum, from the west at that of minimum pressure. Combining the two components and supposing this double variation to act alone on the wind vane, and with equal force in both directions, the result would be a perfectly uniform right-handed rotation of the wind vane once in every twelve hours.

It is evident, on simple inspection, that the Calcutta curve represented on Plate I, Fig. 4, is of a complex character, and cannot be produced even approximately by an oscillation of single period.

The formula* for the diurnal barometric variation at Calcutta being—

$$x = M + \cdot 026548 \sin (n\ 15^\circ + 341^\circ\ 24') + \cdot 039144 \sin (n\ 30^\circ + 151^\circ\ \ 7')$$
$$+ \cdot 001228 \sin (n\ 45^\circ + 346^\circ\ \ 9') + \cdot 001337 \sin (n\ 60^\circ + 253^\circ\ 42')$$

the times of maximum and minimum pressure † are—

1st. Minimum at 3 hours $32\frac{1}{2}$ minutes, civil time.	*2nd.* Minimum at 16 hours 26 minutes, civil time.
1st. Maximum at 9 „ $35\frac{1}{3}$ „ „	*2nd.* Maximum at 24 „ 17 „ „

These are pointed off on the curve, Fig. 4. They do not fall in a line, but it may be noticed that there is a certain symmetry in their positions which may have some significance. If an axis to the curve be drawn midway between the positions of the second or evening minimum and maximum, it also passes about midway between those of the morning maximum and minimum. This is indicated on the figure by the line BC.

The purely geometrical method of analysis, which Mr. F. Chambers has followed in the case of the Bombay curve, being less obviously applicable to the present case, I have resorted to that afforded by Bessel's interpolation formula, which is peculiarly fitted to resolve complex curves such as the present into their principal periodical elements, and to shew the epochs of their several phases. From the figures in the "observation"

* This formula has lately been computed by Babu Brojomohun Rakhit from the hourly observations of 20 years, recorded at the Surveyor-General's Office, Calcutta.

† Obtained by Jelinek's formula $t = \frac{1}{2} - \frac{\Delta_1}{\Delta_2}$ and corrected to a second approximation by the correction $\frac{0 \cdot 2618 f}{\Delta_2}$, when $f =$ the error of the first result.

columns of table D, *viz.*, the northerly and easterly co-ordinates (+ or —) of the diurnal variation, the following formulæ are obtained :—

For the northerly co-ordinates :—

$$x = M + \cdot 7023 \sin (n\,15^\circ + 7^\circ\,23') + \cdot 1902 \sin (n\,30^\circ + 62^\circ\,39')$$
$$+ \cdot 1242 \sin (n\,45^\circ + 274^\circ\,12') + \cdot 0936 \sin (n\,60^\circ + 138^\circ\,48')$$

And for the easterly co-ordinates—

$$x = M + \cdot 2417 \sin (n\,15^\circ + 81^\circ\,29') + \cdot 1644 \sin (n\,30^\circ + 237^\circ\,26')$$
$$+ \cdot 0253 \sin (n\,45^\circ + 16^\circ\,56') + \cdot 0710 \sin (n\,60^\circ + 161^\circ\,57')$$

The first or constant terms of the formulæ (M) represent the co-ordinates of the point A, Fig. 4, and need not here be considered, since we have to do only with the phases of the variation about that point. The corrected values of the hourly co-ordinates computed from the formulæ are given in the 'computed' columns of Table D, and the curve constructed from them is represented by Fig. 5, Plate I. Figs. 6 and 7 shew the curves afforded by the two sets of co-ordinates separately plotted.

Now we may assume that the first periodical terms of the two formulæ, which depend on the values of $n\,15^\circ$, include the greater part of the diurnal variation of the sea and land breezes, and also of any other local oscillation of the winds which depends directly on the diurnal action of the sun. The two series of co-ordinates depending on these terms evidently attain their respective maxima (positive and negative) at alternate intervals of about five and seven hours; and the curve plotted from them is almost an ellipse, having its major axis in the direction N. 5° E. to S. 5° W. This is represented by the dotted curve in Fig. 5. The major axis of the figure, DE, evidently coincides with the line BAC on Fig. 4, and also approximately with the average direction of the wind resultant in April on the one hand, and in November and December on the other, these being the months when the winds are most steady, and blow almost directly from and to the Hooghly estuary. It may be concluded with much confidence that this axis then really represents the mean direction of the diurnal sea and land breezes; the former of which therefore attains its greatest strength about two hours later than the maximum temperature of the day,* and the latter about an hour before sunrise, or half an hour earlier than the minimum.

If these conclusions be admitted, it follows that the greater part of the east and west variation, which, though less important than the above, is not inconsiderable, must depend on other conditions. Its maximum values in opposite azimuths fall about noon and midnight,; and there can be little doubt that it mainly represents the well-known day land wind from the interior of the peninsula, which, in the hot weather is felt most strongly about noon and the early hours of the afternoon; sometimes as a hot wind; and also the easterly tendency of the wind at night, which though perhaps less noticeable and familiar than the former, is well shewn in the hourly wind tables

* On the average of the year the minimum temperature occurs at 5 hours 36½ minutes, and the maximum at 14 hours 25½ minutes, or 2 hours 25½ minutes p. m. The statement in the text is of course only a rough approximation to the truth. The co-efficient of the third periodical term (depending on $n\,45^\circ$) is of appreciable magnitude, and probably, chiefly represents, a subordinate variation of the land and sea breezes.

(Table C) for March, April and May more especially, and is a well-known phenomenon up the Gangetic plain on the approach of the rains.

It is to be observed that this element of the diurnal variation differs by about six hours in phase from the barometric variation of the single diurnal period expressed by the first periodical term of Bessel's formula for that element; which fact, physically interpreted, indicates that the movement of the wind from the westward (in so far as it depends on a single diurnal oscillation) takes place during the fall of pressure depending on a single oscillation, and is at its maximum midway in the fall. We shall see presently that the phases of the wind and pressure, in so far as they depend on the double or semi-diurnal oscillation expressed by the second periodical term of Bessel's formula, in each case exhibit the like relation, and still more closely.

The appearance of this variation, as an element of the mean diurnal wind curve of the year, depends almost entirely on its high value in the first five months, *viz.*, the dry season of the year. In the earlier cold-weather months it is very small, and during the south-west monsoon its phases are reversed, in consequence of which the rotation of the diurnal component of the wind is direct and not retrograde. But this last phenomenon is clearly due, mainly, to the general easterly direction of the wind in those months, combined with the fact that, whatever be the prevailing direction of the wind, its rate of movement is much accelerated in the day time; as may be seen in Table A (appendix) and also in Plates III and IV: and this effect neutralizes and over-masters the diurnal variation now in question, which, moreover, as will afterwards be shewn, is then probably almost evanescent. But that it is a real and independent phenomenon of the diurnal variation, is, I think, sufficiently established by the consideration that, whereas on the mean of the year, easterly elements predominate in the resultant diurnal movement of the wind (see page 4), and might, therefore, be expected to preponderate more in the day than in the night hours, the reverse is manifestly the case. Nor will the high friction error of the recording anemometer account for the variation in question. On the contrary, it is probable that were this corrected, the phenomenon would stand out only the more distinctly. The effect of friction in reducing the recorded movement of the air is very much higher with low than with high velocities, as is indeed amply evident from the table on page 3. Now in all those months in which the movement of the air from the eastward is greater in the day than in the night, the ratio of recorded night movement to that of the day is less than in the months of March, April and May. Hence, by correcting for friction, the mean easterly movement of the night winds will be increased in a greater ratio than that of the day winds in those months. I shall treat at length of this subject in another place, and shall then endeavour to trace out the physical explanation of the oscillation.

The next important element of the diurnal wind variation is that which undergoes a complete revolution in every 12 hours, and is expressed by the second periodical term of Bessel's formula for the two co-ordinates. The existence of this variation, as regards direction, was first detected by Mr. F. Chambers in his discussion of the Bombay wind registers; and he pointed out its apparent coincidence with the barometric tides, and surmised it to be a phenomenon of equal generality. Mr. Chambers, indeed, endeavoured

to shew how the barometric tides might be supposed to be generated as a consequence, (if I have understood him rightly,) of the double diurnal oscillation of the wind. The present results show that the double diurnal oscillation is an element of even greater relative importance in the Calcutta than in the Bombay wind system, but its relations to the barometric tides differ from those described by Mr. Chambers in many important respects; and so far from regarding it as a possible *cause* of the tides, a view which I am unable to reconcile with mechanical laws, it seems to me to be more probably a common effect of the same cause that produces the barometric tides, and to depend (as regards Bombay and, in part, Calcutta), not on the mere existence of those oscillations of pressure, but rather on their difference over land and sea. Consequently the diurnal variation of the wind is probably not a phenomenon of universal occurrence, or at all events of uniform type, but one depending on local conditions and varying with them.

It is evident on simple inspection of the wind formulæ at page 11, that the second periodical term of the formula for the north and south co-ordinates will have a maximum (positive or) northerly value about 1 h. 30 min. a. m. and p. m., and a maximum southerly value about 7 h. 30 min. a. m. and p. m.* Consequently the change from north to south values takes place about 4 h. 30 min. a. m. and p. m., and in the opposite direction about 10 h. 30 min. a. m. and p. m. Similarly, the second periodical term of the formula for east and west co-ordinates will attain a maximum (negative or) westerly value about 1 hour 5 minutes a. m. and p. m., and a maximum easterly value about 7 hours 5 minutes a. m. and p. m. On turning to the barometric formula at page 10, it is equally apparent that the zero values of the second periodical term will fall about 1 and 7 a. m. and p. m. Consequently the wind, in so far as it depends on the semi-diurnal oscillation, blows from the north-west during the falling barometric tide, and from the south-east during the rising tide, the changes taking place about half an hour later than the barometric semi-diurnal maxima and minima.

Seeing that as regards the east and west variations of single period, the relation of wind to pressure is of exactly the same kind as the above, the conclusion seems irresistible that there is a close physical connection between the two phenomena. As regards the north and south variations of single period, any part of it that may depend on the barometric tides is inseparable from the merely local land and sea breezes.

The relation here manifested is, however, of a very different kind from that which Mr. Chambers has shown to exist at Bombay. At that place the north and south components of the semi-diurnal variation have indeed their maximum values at about the same hours as at Calcutta, but the directions are reversed; the tendency of the wind being from the south during the falling and from the north during the rising pressure. The east and west variation on the other hand differs by 3 hours in phase from the above, so that the greatest easterly movement (dependent on the semi-diurnal variation) coincides with the minimum, and the greatest westerly movement with maximum pressure.

Now these facts, taken in connection with the geographical positions of the two places (on opposite sides of the peninsula), suggest, at all events, the probability that

* In the anemometric formula $n=0$ corresponds to the wind's movement between midnight and 1 a. m., consequently to the mean hour *0* h. 30 min.; whereas in the barometric formula $n=0$ corresponds to midnight.

D

the physical contrast of the land and water may be not unconcerned in the phenomenon; and looking more closely at the facts, it appears that, as far as can be judged from the evidence of only two stations, the tendency of the winds is anti-cyclonic around the peninsula during the falling pressure, and cyclonic during the rising pressure; these tendencies manifesting themselves in the mean diurnal wind-curves only as modifying the more important oscillation of single period.

To pursue this subject further will involve an enquiry into the variations of the barometric tides and into the causes and consequences of that hitherto perplexing class of phenomena; and, treated merely as a digression from the main subject of this monograph, would unduly extend the limits of the discussion. I here content myself, therefore, with pointing out the general character of the relations of the wind variation to the oscillations of pressure, and reserve the fuller treatment of these relations for another occasion.

Before concluding this part of the discussion, it remains to say a few words respecting the changes which the diurnal variation of the wind undergoes at different seasons. These are shewn by Table C (Appendix); and graphically in Plates III, IV, and V. I have not attempted to correct the curves of the individual months by the interpolation formula, since I do not think the data are as yet sufficient to admit of being so treated with advantage. I shall only direct attention to one principal point, wherein certain of the monthly curves deviate from the normal curve of the year given on Plate I, Figs. 4 and 5.

In the first place, all the curves are more or less modified according to the direction of the diurnal resultant, since the movement always tends to be greater in that direction as the temperature of the day increases, and *vice versâ*. Thus it happens that in November and December, when the resultant is almost due north, the north component of the diurnal variation is greatest about noon, and in the early morning hours has only about the same value as at sunset; and in July, August and September the diurnal rotation is direct instead of being retrograde. The diurnal acceleration of the wind is however not the only cause of this modification, which implies a greater movement of the air from the eastward during the day than during the night hours, and therefore the reversal of the normal east and west oscillation of single period. I have remarked already on the approximate coincidence of this oscillation with that of the barometer as expressed by the first periodical term of Bessel's formula. Now the magnitude of this term depends on the inequality of the two diurnal waves of pressure, and this inequality is at its maximum in the dry hot-weather months, and becomes very small during the rains (Comp. Figs. 9 and 10, Plate II). Elsewhere I shall endeavour to shew the physical relation that obtains between these phenomena.

Figs. 5 to 8, Plate II, have reference to this relation, and illustrate the inequality of the semi-diurnal barometric tides over a dry land area, and their approximate equality over the sea; in consequence of which, if the *mean* pressure over land and sea is equal, there must be a tendency of the wind to blow from the land during the day, and from the sea during the night, directions the reverse of those of the coast winds.

PART II.

THE THERMAL, BARIC, AND HYETIC WIND-ROSE.—Since the direction of the wind in Calcutta is different and characteristic in each month of the year, and since the annual variations of temperature, pressure, and rainfall are equally marked and characteristic, it is clear that, on the average of the year, each wind will correspond to a certain well-defined phase of the annual variation of these elements, and wind-roses constructed from such data will exhibit features of a very decided character, but such as depend on the season of the year rather than on the direction of the wind regarded *per se*. Thus, a north wind will correspond approximately to the mean temperature of November and December, a south south-west wind to that of the hot-weather months, &c. To a less degree, the temperature corresponding to each wind will be influenced by the diurnal variation, since both these elements follow a diurnal cycle; westerly winds being most prevalent during the hottest hours, northerly winds in the early morning, and southerly in the evening hours. The thermal and baric relations of the Calcutta winds, thus regarded, have already been discussed by Dove;* and it does not seem necessary to repeat here facts which are by this time sufficiently familiar; my object in the present discussion being rather to ascertain what variations of temperature, pressure, and rainfall characterize the different wind directions, after eliminating all that is peculiar to particular seasons or hours of the day.

When this is done, the differences of temperature, &c., which remain outstanding, are, as might be anticipated, comparatively small, and their relations to the several winds are far from constant, varying indeed from month to month. Thus, in February, the warmest wind is from the south, in March from south-west, in April from north-west, and in May from south, and similar changes are exhibited in the relations of the winds to variations of barometric pressure, and even rainfall.

TEMPERATURE.—Table III below, exhibits the variations of the thermal wind-rose for each month of the year, as computed from the hourly observations of six years. That for each month is therefore based on an average of 4,320 observations. In computing this table, the observations of temperature have first been tabulated under each of the eight principal wind directions separately, and their mean values extracted. A correction has then been applied to eliminate the effects of the diurnal variation; which correction has been obtained by multiplying the mean temperature anomaly for each hour by the number of wind observations in each octant recorded at that hour, and dividing the sum of the products for each octant by the sum of the observations. From the series of temperatures for each month, thus corrected, have been computed the rectangular co-ordinates of the first two periodical terms of Bessels formula, for that month. Lastly, the annual series of the rectangular co-ordinates of the corresponding terms of the monthly formulæ have themselves been treated by the same

* Meteorologische Mittheilungen, 1837, pages 301 to 327.

process, and the temperatures of Table III have been computed from the corrected formulæ. In the general formula $x = M + U' \sin(n\,45° \; u') + U'' \sin(n\,90° + u'')$ the corrected co-efficients U', u', U'', u'', are as follow:—

	U'	u'	U''	u''
January	0·691	254° 46′	1·212	65° 54′
February	1·420	234° 47′	0·607	55° 4′
March	1·582	200° 51′	0·096	3° 18′
April	1·487	185° 51′	0·688	101° 12′
May	0·951	256° 18′	1·115	91° 27′
June	2·119	308° 28′	0·536	43° 13′
July	1·976	323° 40′	0·632	343° 15′
August	0·822	330° 50′	0·483	47° 8′
September	0·487	294° 5′	0·575	92° 34′
October	0·786	312° 27′	0·294	274° 7′
November	0·793	353° 53′	0·742	297° 13′
December	0·435	13° 0′	0·637	34° 13′

TABLE III.—Mean temperature variation of the winds in each month, after elimination of the diurnal variation.

Months.	Mean.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
January	67·8	+0·44	−0·11	−1·29	−0·15	+1·77	+1·09	−0·92	−0·84
February	73·0	−0·66	−1·05	−1·32	−0·11	+1·66	+1·75	+0·32	−0·59
March	80·4	−0·56	−1·35	−1·48	−0·74	+0·57	+1·54	+1·47	+0·55
April ..	84·7	+0·52	−1·29	−2·15	−0·80	+0·83	+1·02	+0·80	+1·07
May	85·9	+0·19	−0·84	−1·34	+0·52	+2·04	+0·78	−0·89	−0·47
June	84·9	−1·29	+0·15	+0·95	+1·71	+2·03	+0·63	−1·69	−2·50
July	83·4	−1·35	+0·90	+1·77	+1·35	+0·99	+0·31	−1·41	−2·56
August	83·1	−0·05	+0·55	+0·36	+0·46	+0·75	+0·10	−1·07	−1·12
September ...	83·3	+0·13	−0·20	−0·38	+0·48	+1·02	+0·15	−0·77	−0·43
October	81·6	−0·87	−0·01	+0·82	+0·76	+0·29	+0·06	−0·24	−0·81
November ...	74·9	−0·74	+0·84	+1·45	+0·28	−0·58	−0·16	−0·13	−0·96
December... ...	68·0	+0·46	+0·90	+0·07	−0·30	+0·26	+0·16	−0·78	−0·76
Year ...	79·3	−0·32	−0·13	−0·21	+0·29	+0·97	+0·62	−0·44	−0·78

The results of this table are represented graphically in the thermal wind-roses given on Plate VI, Figs. 14 to 18, and Plate VII, Figs. 1 to 8.

Hence, on the average of the year, south, or more accurately, S. 7° W. is the warmest quarter, and north-west the coolest; the former being the direction of the wind that blows up the Hooghly estuary, the latter that of the land wind from the Upper Provinces. But their extreme difference, after eliminating the effects of the annual and diurnal variation of temperature, is but 1·75°.

The variations in the relative temperatures of the several wind currents, exhibited in the foregoing table, are curious and instructive. In October, at the end of the rains, the warmest quarter is about east-south-east, which is that from which the expiring monsoon blows most strongly; and the coolest about north-north-west. In November the former shifts to east, while the latter is a little more westerly. In December a further change takes place still in the same direction, and at the same time a secondary maximum begins to appear in the south, which in January becomes the principal maximum, while the northerly maximum tends to disappear.. After this the increasing heat of the land wind from the Upper Provinces during the spring months is shewn by the direction of maximum temperature working round from south through west to north-west. But in May it returns to south, the winds from west and north-west in this month being chiefly those which accompany north-westers, in which case their temperature is reduced by the evaporation of the rain.* During the rainy season, which follows, the direction of the warmest wind coincides approximately with that which is most prevalent, but is more easterly in July than either in the preceding or following months; while in September the thermal wind-rose is very similar to that of January.

On the whole, the evidence of the thermal wind-rose of Calcutta accords with the conclusions formerly arrived at from the discussion of the winds of Northern India, *viz.*, that the winds are either drawn from the sea to the south, or originate in the interior of India, and their temperature varies with that of the region from which they proceed. Polar currents, properly so called, play no part in the wind system of Bengal.

PRESSURE.—The baric wind-rose has been computed in the same manner as the thermal wind-rose and from similar data; the means having been duly corrected for the diurnal variation of pressure before being treated by Bessel's formula.

The corrected co-efficients of the formula for the baric wind-rose of each month are as follow :—

	U'	u'	U''	u''
January	·0334	84°19′	·0095	36° 2′
February	·0393	75°35′	·0066	313°19′
March	·0240	80° 8′	·0069	288°26′
April	·0178	66°53′	·0065	246°34′
May	·0256	60°44′	·0055	155°18′
June	·0136	49°46′	·0134	110°27′
July	·0221	264° 2′	·0177	106°44′
August	·0342	251°56′	·0145	101° 5′
Sepetmber	·0148	203°58′	·0079	112° 4′
October	·0230	125° 5′	·0040	122°54′
November	·0197	110°27′	·0045	79°55′
December	·0192	73°39′	·0056	53°55′

from which the following table has been computed.

* See Table VI.

TABLE IV.—Mean barometric variation of the winds in each month after eliminating the diurnal variation.

Month.	Mean.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.
January	30·012	+·039	+·034	—·002	—·028	—·027	—·018	—·009	+·013
February	29·917	+·037	+·040	+·010	—·027	—·039	—·027	—·009	+·013
March	·855	+·017	+·022	+·011	—·016	—·030	—·017	+·002	+·012
April	·758	+·010	+·014	+·013	—·004	—·022	—·019	—·001	+·009
May	·641	+·025	+·020	+·010	—·002	—·020	—·030	—·015	+·012
June	·541	+·023	+·009	—·004	+·004	+·002	—·018	—·021	+·006
July	·532	—·005	—·020	—·020	+·017	+·039	+·014	—·015	—·011
August	·590	—·018	—·033	—·025	+·018	+·047	+·028	—·004	—·013
September	·681	+·001	—·017	—·021	—·002	+·013	+·011	+·006	+·008
October	·820	+·022	+·002	—·017	—·020	—·015	—·006	+·010	+·025
November	·959	+·023	+·009	—·011	—·019	—·014	—·007	+·002	+·017
December	30·023	+·025	+·022	—·002	—·014	—·011	—·012	—·012	+·004
Year	29·780	+·017	+·008	—·005	—·008	—·007	—·008	—·006	+·008

The results of this table are shewn in a graphical form in the baric wind roses on Plate VI, Figs. 1 to 13.

This table shews that on the average of the year, after eliminating the annual and diurnal variations, the highest pressures accompany north winds, and lowest those from between south-east and south-west. The former direction does not exactly coincide with that of lowest mean temperature, nor do the latter correspond very definitely with that of the highest temperature, although regarded generally this relation does hold good. The variations of pressure which characterise the different quarters are at all times of the year very small, and the extremes never differ by so much as 0·1 inch.

Through the dry months of the year, *viz.*, from October to April, the quarter of highest pressure veers gradually from north-west to north-east, and that of the lowest from south-east to south-west, *i. e.*, against the direction of the wind's rotation. In May the former veers to north, but with the beginning of the rains the pressure rises with winds from south and south-east; and from July to September, south is the quarter of highest pressure, and north-east or east-north-east the lowest. At the close of the rains in October, the change to the cold-weather distribution takes place by a rapid shift of both maximum and minimum, the former to north-north-west, the latter to south-east, from which quarters they continue to veer in the subsequent months as already described.

Comparing the results of Table IV with those of Table III, it is evident that at Calcutta no such relation exists between temperature and pressure as was established by Dove in the case of the winds of Europe. In the cold-weather months the highest pressures tend to coincide rather with the lower temperatures, while in the rainy months the opposite relation holds good. Nor is the relation of pressure to the humidity of the wind (as tested by the proportional rainfall) more definite and constant, for while

in the hot-weather months the highest pressures coincide with the wettest winds, the opposite rule holds good in the rains. When the physical meteorology of the country shall be better understood, it will probably be found that the variations in the wind directions depend on certain anomalies in the distribution of pressure; there is no reason whatever to conclude from the data now before us that the variations in the density of the lower currents of the atmosphere arising from variations in the characteristic temperature and humidity of the place of their origin, are the most potent causes of non-periodic variations in the local pressure.

Rainfall.—The relation of rainfall to wind direction may be regarded from two very different points of view. By far the greater proportion of the rain that falls at Calcutta is brought by winds from between east and south-west, that being the prevalent direction of the winds during the rainy season; and the direction of most frequent rainfall is about south by east. But if we estimate the wetness of the winds as proportional to the percentage of the whole number from each quarter that are accompanied by rain, the result is somewhat different. It then appears that the hyetic wind-rose presents two maxima and two minima, an absolute maximum at almost due east, and a secondary maximum at south-west, while the absolute minimum corresponds to north-west by north, and a secondary minimum to south ½ west, which very nearly coincides with the direction of the absolutely greatest or at least most frequent fall. The data upon which this generalization is based are given in the accompanying Tables V and VI. The first shews the number of winds observed in each month during 10 years, arranged under 8 points of the compass, and also the number that were accompanied by rain. It is very evident that in both cases the accuracy of the estimate of direction is impaired by the observer's tendency to refer an undue proportion of winds to the four cardinal points, but we may fairly assume that this error affects both parts of the table equally, and the percentage proportion of the rainfall to the frequency of *the several winds in Table VI is probably a near approximation to the truth.*

Table V.—Number of winds and winds with rain observed hourly during ten years at Calcutta.

Month.	Winds observed.									Winds with rain.								
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
January ...	2,003	203	356	159	651	517	984	1,253	121	18	...	15	6	5	6	4	6	...
February ...	840	331	453	205	1,215	775	1,069	842	39	17	6	29	2	13	11	10	8	...
March ...	406	151	233	277	2,470	1,198	1,006	515	30	15	21	13	10	8	10	16	4	...
April ...	116	102	280	677	3,684	646	295	117	31	12	10	8	19	38	14	12	15	...
May ...	162	101	621	1,141	3,211	607	161	112	95	29	26	48	53	69	23	17	30	1
June ...	185	288	650	870	2,841	849	309	159	141	39	35	99	101	184	175	98	31	8
July ...	110	210	713	1,159	6,056	812	253	61	77	37	40	117	169	377	168	85	23	6
August ...	137	310	974	1,119	2,470	735	312	96	121	35	53	164	202	337	137	84	18	4
September	310	524	1,028	1,019	1,965	479	407	224	162	67	94	152	111	112	50	59	13	5
October ...	1,292	410	582	509	1,039	457	941	928	173	30	48	107	53	61	14	29	47	...
November	2,199	621	336	126	155	283	736	1,421	61	28	15	18	9	4	...	...	...	...
December	2,380	899	173	68	209	262	846	1,658	53	10	15	3	1	3	...	1	7	...
Year ...	10,536	8,826	6,299	7,451	23,065	7,841	7,402	7,416	1,084	337	369	773	736	1,241	628	359	205	23

The error above referred to may be approximately eliminated by computing the probable values by means of Bessel's formula, not going beyond the term dependent on $3 n \theta$. Thus treated, we may substitute for the annual sums of the winds with rain in Table V the following values, omitting calms—

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
287	446	660	889	1059	758	332	248

or reduced to the form of percentages of the whole number of rainy winds under the eight points—

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
6·14	9·52	14·10	19·00	22·63	16·25	7·09	5·29

This result is represented graphically in the hyetic wind-rose, Plate VII, Fig. 9.

TABLE VI.—Percentage of rainfalls with winds from each quarter in each month computed from Table V.

Month.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
January	0·90	...	4·21	3·77	0·77	1·16	0·41	0·48	...
February	2·01	1·80	6·40	0·75	1·07	1·42	0·93	0·95	...
March	3·22	13·91	5·58	3·61	0·32	0·84	1·59	0·77	...
April	10·34	9·80	2·86	2·81	1·03	1·65	4·07	10·20	...
May	17·20	13·40	7·73	4·63	2·15	3·70	11·04	26·78	1·05
June	21·08	12·15	18·00	11·49	6·48	20·83	26·56	21·38	5·67
July	33·64	19·16	16·41	14·58	12·34	23·15	33·60	37·70	6·49
August	25·55	15·59	16·84	17·58	13·64	18·64	24·56	18·75	3·30
September	19·71	17·94	14·78	10·58	7·23	10·44	9·58	5·80	3·29
October	2·32	10·91	18·38	10·41	5·87	2·87	3·08	5·06	...
November	1·12	2·68	5·36	7·14	2·58	...	...	...	...
December	0·42	3·76	1·73	1·72	1·00	...	0·12	0·42	...
Year	3·20	9·64	12·27	9·88	5·38	8·01	5·25	2·76	2·12

Table VI is very instructive, and seems to establish a fact of much importance with respect to the probabilities of rainfall. The wind direction which is most prevalent in the rains, and which may be regarded therefore as the normal direction of the summer monsoon current, although, *on the whole*, it brings more rain than any other, does so in virtue of its greater prevalence, and by no means in proportion to its frequency. On the contrary, rain is proportionally less characteristic of this wind than of any other. *It is therefore not when the monsoon current is blowing steadily that rain is most probable, but when it is deflected from its normal direction by some local irregularity of pressure, and rain is the more probable in proportion as this deflection is greater.*

This may be and possibly is a law of local application only, and may not not hold good for the interior, where westerly winds at all times of the year are dry winds: and this inference receives some support from the fact that at Calcutta itself, there is an exception to the law in the case of the north-west wind in August and September; in consequence of which, instead of the wind-rose of rain-probability presenting a single relative maximum almost diametrically opposite to the direction of greatest prevalence, two maxima (*viz.*, W. or SW. and N.) result, separated by a comparatively dry quarter.

With this exception, however, the rule would seem to hold good more or less throughout the year. This is shewn very distinctly in the following table, in which I have thrown together the results of the several months to give the mean of the three Indian seasons, *viz.*, (1) the cold weather, October to February; (2) the hot weather, March to May; (3) the rains, June to September; and have corrected the percentages by Bessel's formula computed to three periodical terms. The coefficients are—

	M	U'	u'	U''	u''	U'''	u'''
(1) October to February, ...	3·32	3·578	317°35′	1·616	252°55′	0·619	174°33′
(2) March to May, ...	5·33	4·546	60°11′	1·075	354°16′	1·103	313°58′
(3) June to September, ...	17·17	4·032	127°27′	1·947	315° 9′	3·347	80°18′

and the several values thence computed, together with the quarters of greatest and least relative rainfall probability, as follow. I have added the mean wind direction of the season, deduced from the data in Table V. Figs. 10 to 12, Plate VII, illustrate graphically the facts shewn numerically in the table.

Table VII.—Percentage probability of rain with winds from each quarter at the three seasons of India.

	Percentage probability of rainfall.								Least rainy wind.	Most rainy wind.	Mean wind direction.
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.			
October to February ...	1·06	4·29	8·97	6·62	2·49	1·40	0·76	1·17	W. ½ N.	E. ½ S.	N. W. by N.
March to May ...	8·37	11·89	6·93	3·05	2·07	0·91	3·91	5·47	S. W. by S.	N. E. ½ N.	S. ½ W.
June to September ...	22·30	17·15	15·53	14·53	9·30	19·95	21·56	17·05	S. by E.	N.	S. by E.

In the drier season of the year, therefore, *i. e.*, in the cold and hot weather, the direction of the most rainy wind is not diametrically opposite to that of the most prevalent wind, but is deflected from it three or four points to the eastward of the opposite quarter, but in the rains the deflection amounts to one point only.

The conclusions arrived at in this discussion may be summed up as follow:—

(1.) When that variation of temperature which depends on the season of the year or the hour of the day (in general terms on the direct influence of the sun) is eliminated, the relative temperature of each wind varies according to the relative temperature of the region from which it proceeds. The land wind from the interior is the cooler when the mean temperature of the land is lower than that of the sea, and *vice versâ*. The month of May presents an exception to the rule, which is explained by the fact that in that month the winds from the interior meeting those from the sea give rise to storms, which cool them by the evaporation of the fallen rain.

(2.) When those variations of pressure that depend on the season of the year and the hour of the day are eliminated, the pressure characteristic of each wind direction is found not to vary either as the temperature or the relative humidity of the

current.* In the rainy season the highest pressures occur with the winds which are most prevalent at that season, and as the pressure falls, so do they tend to deviate from the normal direction. In the earlier part of the dry season the highest pressures occur with winds from the north-west and north, in the later part with those from the north-east. In general, it may be inferred that the direction of the wind is determined by the local distribution of pressure, and not the latter by the former.

(3.) On the average of the year by far the greater quantity of rain comes with winds from between south and south-east, but this chiefly depends on the fact that these winds are the characteristic winds of the rainy season, and partly that they are more prevalent than those from other quarters. The probability of rain with a given wind at any season is, as a general rule, the greater, the less seasonable the wind from that quarter, but the probability is increased the more easterly the direction.

* The relative humidity being assumed as proportional to the frequency of rainfall relatively to the frequency of the wind from each quarter.

TABLE A.

Mean movement of air (irrespective of direction) in each hour of each month as registered by the Secchi anemograph at St. Xavier's College, Calcutta, from July 1871 *to June* 1875.

DISTANCE IN MILES.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Year.
Mid. to 1...	1·70	2·23	4·31	6·14	7·12	4·87	4·18	2·90	2·75	2·04	1·32	1·34	3·41
1 to 2...	1·65	2·30	4·06	5·83	6·37	5·04	3·96	2·92	2·54	2·16	1·35	1·45	3·30
2 „ 3...	1·48	2·27	3·50	5·53	5·68	4·81	3·68	2·94	2·75	2·05	1·48	1·48	3·14
3 „ 4...	1·62	2·00	3·05	5·04	5·08	4·73	3·63	2·80	2·66	2·20	1·59	1·44	2·99
4 „ 5...	1·69	2·02	2·85	4·72	4·54	4·46	3·69	3·01	2·58	2·13	1·65	1·42	2·90
5 „ 6...	1·65	1·96	2·60	4·96	4·40	5·02	3·99	3·11	2·85	2·25	1·64	1·37	2·99
6 „ 7...	1·56	1·80	3·25	5·81	5·36	6·24	4·90	3·78	3·77	2·66	1·87	1·42	3·53
7 „ 8...	1·76	2·24	4·11	7·69	7·40	7·42	5·70	4·84	5·12	3·78	2·63	1·90	4·55
8 „ 9...	2·53	3·38	5·41	8·23	8·78	8·48	6·66	5·42	6·03	4·35	3·67	2·40	5·44
9 „ 10...	3·46	4·43	5·59	8·77	9·32	8·83	6·94	5·68	6·31	4·99	4·23	3·00	5·97
10 „ 11...	4·07	4·98	5·91	9·20	9·32	7·91	7·29	5·93	6·27	5·26	4·49	3·61	6·20
11 „ noon	3·92	5·19	5·84	8·85	8·93	8·51	7·43	5·94	6·00	5·31	4·48	3·89	6·19
Noon „ 13...	4·25	5·20	6·26	8·98	9·36	9·15	7·65	6·21	6·94	5·44	4·64	3·72	6·48
13 „ 14...	4·17	5·06	6·11	9·45	10·04	9·32	7·79	6·52	7·03	5·16	4·61	3·76	6·59
14 „ 15...	3·92	5·02	6·35	9·52	10·39	9·76	7·73	6·49	6·62	5·34	4·31	3·59	6·59
15 „ 16...	3·22	4·76	6·33	9·85	10·88	9·25	7·58	6·21	6·25	4·67	3·87	3·18	6·34
16 „ 17...	2·75	4·13	6·02	10·24	11·12	8·91	7·27	5·53	5·34	3·73	2·37	2·21	5·80
17 „ 18...	1·74	2·73	5·57	9·39	10·23	7·93	6·15	4·88	4·32	2·36	1·13	1·17	4·80
18 „ 19...	1·57	2·43	6·10	9·36	9·09	7·43	5·23	4·45	4·07	2·03	0·95	1·00	4·48
19 „ 20...	1·68	2·73	6·07	9·22	8·77	6·65	4·84	4·20	4·02	2·26	1·01	0·97	4·37
20 „ 21...	1·87	3·00	5·81	8·46	8·61	6·36	4·67	4·02	3·67	2·20	1·08	0·90	4·22
21 „ 22...	2·05	2·85	5·95	7·97	8·33	5·76	4·69	3·89	3·46	2·15	1·11	1·00	4·10
22 „ 23...	2·08	2·57	5·62	7·34	7·74	5·46	4·64	3·60	3·05	2·00	1·08	1·32	3·87
23 „ 0...	1·96	2·45	5·10	6·57	7·56	5·10	4·45	3·31	2·75	1·88	1·22	1·28	3·64
TOTAL DAILY	58·35	77·73	121·80	187·12	194·42	167·40	134·74	108·58	107·15	78·40	57·78	49·11	111·89
Hourly Mean ...	2·43	3·24	5·08	7·80	8·10	6·97	5·61	4·52	4·46	3·27	2·41	2·05	4·66

TABLE B.

Number of Winds recorded under each Octant of the Compass at each hour in each month of the year at the Surveyor-General's Office, Calcutta, during 10 years.

JANUARY.

Civil hours.	Winds recorded. N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid.)	91	8	14	7	37	14	39	35	17
1 "	99	6	15	7	37	14	39	37	14
2 "	91	7	14	6	39	14	39	41	11
3 "	93	7	14	6	37	16	31	44	11
4 "	93	7	13	5	29	18	29	48	10
5 "	88	8	12	4	28	17	36	45	9
6 "	100	12	9	6	28	20	42	41	7
7 "	101	16	16	7	25	24	35	42	4
8 "	94	22	21	7	23	23	23	36	3
9 "	103	30	19	9	27	22	26	31	1
10 "	97	31	23	10	23	18	34	34	...
11 "	91	26	20	7	35	15	32	45	...
12 (noon)	75	21	15	9	16	24	43	64	...
13 "	63	10	12	5	13	32	52	81	...
14 "	56	7	13	6	13	36	58	80	...
15 "	52	8	9	5	14	25	66	85	...
16 "	70	3	8	6	16	24	60	76	...
17 "	71	5	9	7	20	22	53	75	1
18 "	74	8	15	6	32	21	46	63	2
19 "	82	8	17	7	31	25	43	51	4
20 "	80	10	17	7	29	24	43	50	6
21 "	83	9	18	5	31	24	43	51	7
22 "	78	12	15	7	34	22	39	51	7
23 "	75	12	18	8	34	23	33	47	7
Sums ...	2,003	293	356	159	651	517	984	1,253	121
Per cent....	31·6	4·6	5·6	2·5	10·3	8·1	15·5	19·8	1·9

FEBRUARY.

Civil hours.	Winds recorded. N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid.)	31	6	21	13	76	28	32	31	5
1 "	32	6	19	13	75	34	34	33	5
2 "	31	6	18	14	70	36	34	35	5
3 "	34	6	17	14	63	30	38	34	5
4 "	34	6	13	15	59	27	36	35	5
5 "	42	8	10	14	56	27	37	32	5
6 "	46	13	16	16	53	24	39	36	4
7 "	51	23	18	15	48	21	34	37	1
8 "	43	27	21	11	48	20	27	36	...
9 "	48	30	30	16	38	23	31	29	...
10 "	43	36	28	17	38	25	28	30	...
11 "	41	22	28	13	30	31	43	36	...
12 (noon)	35	24	17	10	31	38	46	44	1
13 "	32	13	14	8	27	38	61	52	...
14 "	26	11	17	12	23	38	66	52	...
15 "	31	8	15	14	19	37	76	45	...
16 "	30	11	11	12	22	34	71	50	...
17 "	27	15	18	8	34	43	68	34	...
18 "	32	14	19	6	52	38	55	27	...
19 "	35	11	18	4	60	39	49	26	1
20 "	33	11	18	5	64	39	46	27	1
21 "	32	9	23	5	71	38	39	27	1
22 "	31	9	22	5	78	35	38	26	...
23 "	26	9	22	5	80	32	41	28	...
Sums ...	846	334	453	265	1,215	775	1,069	842	39
Per cent....	14·5	5·7	7·8	4·5	20·8	13·3	18·3	14·4	0·7

TABLE B.—*continued.*

MARCH.

Civil hours.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
	Winds recorded.								
24 (Mid.)	14	3	8	12	146	43	19	8	1
1 ,,	16	4	8	11	153	44	23	6	1
2 ,,	13	7	8	11	150	45	22	7	3
3 ,,	14	5	9	10	142	42	23	8	4
4 ,,	14	3	7	9	133	46	22	8	4
5 ,,	15	2	7	13	131	48	28	9	3
6 ,,	21	3	8	8	122	58	32	12	1
7 ,,	21	3	13	13	106	57	37	12	1
8 ,,	29	7	12	9	92	67	33	15	...
9 ,,	32	9	9	9	82	73	41	15	...
10 ,,	32	12	7	8	71	78	45	17	...
11 ,,	34	8	7	11	58	61	49	38	...
12 (noon)	31	5	14	14	51	56	57	38	...
13 ,,	18	11	12	9	47	62	65	44	...
14 ,,	23	8	9	10	52	55	72	41	...
15 ,,	20	6	10	5	63	50	83	33	...
16 ,,	14	10	9	6	57	51	79	37	...
17 ,,	18	8	11	10	78	51	64	26	...
18 ,,	15	10	9	15	98	41	50	28	2
19 ,,	18	9	8	15	110	32	42	28	4
20 ,,	14	5	13	15	122	33	40	25	1
21 ,,	12	5	11	17	136	35	28	22	2
22 ,,	15	4	11	18	141	34	25	20	2
23 ,,	13	4	13	19	135	33	27	18	1
Sums ...	466	151	233	277	2,479	1,198	1,006	515	30
Per cent...	7·3	2·4	3·7	4·4	39·0	18·9	15·8	8·0	0·5

APRIL.

Civil hours.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
	Winds recorded.								
24 (Mid.)	2	7	8	36	165	18	3	1	5
1 ,,	3	4	8	37	176	18	3	2	5
2 ,,	5	1	16	32	173	20	3	1	2
3 ,,	3	2	15	34	164	23	7	...	2
4 ,,	3	6	13	36	141	22	6	1	3
5 ,,	4	6	19	32	148	24	8	4	3
6 ,,	6	6	19	37	147	30	11	4	2
7 ,,	5	7	20	38	137	34	14	5	...
8 ,,	7	7	15	27	141	45	9	5	...
9 ,,	6	5	10	27	148	51	11	4	...
10 ,,	6	3	8	19	142	59	19	6	...
11 ,,	8	2	5	21	135	60	19	12	...
12 (noon)	6	3	8	17	135	62	22	9	...
13 ,,	6	3	7	19	139	63	20	5	...
14 ,,	2	2	10	25	129	58	31	4	...
15 ,,	2	5	8	22	138	48	31	6	...
16 ,,	4	3	8	20	140	51	18	12	...
17 ,,	4	1	8	25	163	32	13	13	1
18 ,,	7	4	7	30	162	31	10	12	1
19 ,,	3	5	8	25	178	22	12	11	1
20 ,,	9	6	9	29	170	17	10	9	1
21 ,,	6	6	15	31	170	19	6	8	1
22 ,,	4	4	16	31	170	18	4	6	4
23 ,,	5	4	20	27	173	21	5	7	...
Sums ...	116	102	289	677	3,684	846	295	147	31
Per cent...	1·9	1·6	4·5	11·0	59·6	13·7	4·8	2·4	0·5

TABLE B.—*continued.*

MAY.									
Civil hours.	Winds recorded.								
	N.	N. E	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid.)	8	6	25	47	144	10	6	3	7
1 ,,	8	6	29	49	141	7	7	2	13
2 ,,	7	7	29	48	140	8	5	4	12
3 ,,	6	8	24	49	128	10	5	5	10
4 ,,	6	6	19	53	126	10	6	6	8
5 ,,	10	9	28	50	128	14	10	5	6
6 ,,	13	13	35	51	121	14	7	6	4
7 ,,	12	17	35	55	123	16	4	6	...
8 ,,	5	11	26	55	130	32	1	3	1
9 ,,	6	10	25	36	135	40	3	3	...
10 ,,	5	3	24	33	144	40	4	6	...
11 ,,	7	4	18	34	147	40	8	4	1
12 (noon)	7	6	14	45	138	50	9	3	...
13 ,,	6	8	16	40	130	49	15	5	1
14 ,,	4	10	16	39	123	54	13	10	...
15 ,,	5	7	18	47	132	42	10	6	...
16 ,,	10	9	20	46	128	40	8	3	...
17 ,,	8	10	18	44	146	29	5	3	2
18 ,,	5	7	28	51	134	28	5	6	1
19 ,,	9	9	31	51	140	11	5	5	4
20 ,,	5	9	33	54	131	16	6	7	6
21 ,,	4	8	35	56	129	15	5	4	7
22 ,,	3	6	38	56	133	14	4	4	6
23 ,,	3	5	37	55	134	18	3	3	6
Sums ...	162	194	621	1,144	3,211	607	154	112	95
Per cent. ...	2 6	3·1	9·9	18·1	51·0	9·6	2·4	1·8	1·5

JUNE.									
Civil hours.	Winds recorded.								
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid.)	8	7	22	36	125	22	10	6	18
1 ,,	6	9	22	37	130	22	11	5	20
2 ,,	6	8	27	34	127	25	12	4	18
3 ,,	6	8	27	34	115	25	14	3	9
4 ,,	6	10	30	34	111	24	16	4	5
5 ,,	11	15	20	41	115	27	15	7	3
6 ,,	12	20	27	42	111	34	12	6	1
7 ,,	9	21	24	38	103	41	20	7	...
8 ,,	12	16	32	27	108	41	17	5	...
9 ,,	12	11	32	22	117	44	20	6	1
10 ,,	11	13	28	28	106	45	24	10	1
11 ,,	7	16	22	28	103	57	16	16	...
12 (noon)	8	17	20	29	106	46	28	12	...
13 ,,	5	13	17	36	112	48	22	12	...
14 ,,	8	15	23	38	105	46	22	8	...
15 ,,	4	13	24	40	106	41	26	10	1
16 ,,	5	13	17	43	114	35	20	10	3
17 ,,	7	14	13	42	130	34	12	4	6
18 ,,	5	6	23	45	133	33	14	2	4
19 ,,	7	9	21	45	133	35	6	4	5
20 ,,	8	7	18	40	133	33	7	4	13
21 ,,	7	10	19	36	139	27	10	4	13
22 ,,	7	10	20	41	132	28	8	4	11
23 ,,	8	7	22	43	127	27	7	6	9
Sums ...	185	288	550	879	2,841	840	369	159	141
Per cent. ...	2·9	4·6	8·6	14·0	45·4	13·4	5·9	2·5	2·2

TABLE B.—*continued.*

Civil hours.	JULY. Winds recorded. N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	Civil hours.	AUGUST. Winds recorded. N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid.)	6	4	21	46	138	21	4	1	10	24 (Mid.)	2	8	41	43	122	15	10	3	12
1 „	3	7	30	55	137	22	6	1	12	1 „	3	9	46	47	121	20	8	3	15
2 „	3	7	31	55	137	20	5	1	8	2 „	3	8	45	51	117	19	7	3	13
3 „	4	5	36	54	127	21	8	2	6	3 „	4	10	42	55	107	17	7	3	13
4 „	3	7	36	45	123	17	8	1	7	4 „	5	7	40	50	101	19	8	3	6
5 „	4	12	36	47	122	25	9	2	3	5 „	8	12	45	49	100	26	15	3	4
6 „	5	18	32	50	129	28	7	5	2	6 „	9	15	50	42	99	35	12	5	2
7 „	5	16	36	53	120	33	9	4	1	7 „	9	17	59	48	82	33	14	6	1
8 „	4	9	36	51	110	40	8	5	1	8 „	11	16	53	33	77	42	18	6	1
9 „	7	11	35	48	111	42	18	2	...	9 „	7	26	47	37	81	41	20	5	1
10 „	7	12	30	43	123	46	13	1	...	10 „	10	25	43	41	83	46	19	4	1
11 „	3	14	29	45	101	53	18	5	...	11 „	7	26	37	41	81	41	21	2	...
12 (noon)	4	11	22	46	112	51	18	5	...	12 (noon)	5	31	30	46	79	59	22	7	...
13 „	6	13	21	47	109	48	22	5	...	13 „	7	22	39	45	77	42	21	6	...
14 „	8	9	27	47	106	51	16	5	1	14 „	9	18	35	45	92	49	16	4	1
15 „	6	11	22	48	117	52	12	6	1	15 „	7	16	39	43	95	50	12	7	...
16 „	4	8	25	39	123	53	11	5	3	16 „	6	12	28	59	96	45	12	6	...
17 „	3	9	23	48	138	39	8	2	3	17 „	4	11	30	57	101	36	12	6	4
18 „	4	10	26	51	140	33	11	2	2	18 „	4	11	26	63	115	25	17	7	4
19 „	5	11	26	43	146	30	10	...	2	19 „	5	10	37	47	125	22	13	3	7
20 „	5	8	29	45	150	22	8	...	5	20 „	3	9	41	49	127	17	13	1	9
21 „	4	9	30	50	147	21	7	...	5	21 „	3	8	43	49	125	15	12	1	11
22 „	4	9	37	51	146	19	8	...	2	22 „	3	6	39	52	129	14	13	1	9
23 „	3	10	31	52	141	22	9	1	3	23 „	3	7	36	51	129	13	11	1	7
Sums ...	110	240	713	1,159	3,036	812	253	61	77	Sums ...	137	340	974	1,149	2,470	735	312	96	121
Per cent. ...	1·7	3·7	11·0	17·9	47·1	12·5	3·9	0·9	1·2	Per cent....	2·1	5·3	15·3	18·1	38·8	11·5	5·4	1·5	1·9

TABLE B.—*continued.*

SEPTEMBER.									
	Winds recorded.								
Civil hours.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid)	10	20	39	46	93	11	11	5	19
1 „	11	18	39	36	98	11	12	7	19
2 „	13	16	41	45	98	10	13	8	15
3 „	13	18	43	39	96	10	10	8	12
4 „	12	14	48	35	83	11	11	8	13
5 „	12	15	49	35	82	19	13	9	10
6 „	15	22	44	44	83	17	20	8	9
7 „	16	26	53	41	78	15	14	12	9
8 „	17	31	49	40	61	19	23	11	..
9 „	17	29	49	37	70	18	28	10	...
10 „	18	24	57	38	70	14	30	12	...
11 „	15	26	47	51	66	22	21	14	...
12 (noon)	11	35	37	51	60	28	24	15	...
13 „	18	30	41	51	55	33	21	12	...
14 „	16	26	40	53	60	33	20	12	...
15 „	11	25	35	53	70	33	13	19	...
16 „	17	27	31	49	74	33	16	10	1
17 „	14	21	39	48	91	19	17	11	1
18 „	17	21	40	46	91	21	18	6	2
19 „	20	16	38	41	99	20	16	4	7
20 „	14	16	42	42	97	21	14	4	11
21 „	12	17	41	40	100	18	15	5	9
22 „	10	14	46	42	97	22	13	7	7
23 „	11	17	40	46	93	21	14	7	8
Sums ...	340	524	1,028	1,049	1,965	479	407	224	152
Per cent.	5·5	8·5	16·7	17·0	31·8	7·8	6·6	3·6	2·5

OCTOBER.									
	Winds recorded.								
Civil hours.	N.	N. E.	E.	S. E	S.	S. W.	W.	N. W.	Calm.
24 (Mid)	48	13	25	21	53	18	28	27	24
1 „	49	14	26	21	56	19	29	26	22
2 „	50	15	26	24	53	19	30	26	21
3 „	46	15	27	22	46	20	29	26	18
4 „	49	13	28	24	45	19	28	30	13
5 „	49	13	23	25	51	19	32	28	10
6 „	57	13	21	31	49	22	31	38	9
7 „	57	21	25	27	45	28	32	31	4
8 „	68	22	26	17	35	23	37	24	1
9 „	66	31	26	19	40	19	37	27	...
10 „	53	31	32	17	39	19	41	36	...
11 „	54	25	29	19	32	28	40	41	...
12(noon)	48	25	22	23	32	27	46	46	...
13 „	49	22	19	21	28	20	50	57	1
14 „	50	22	17	23	25	23	53	52	...
15 „	46	18	21	18	26	28	52	53	...
16 „	49	15	15	20	30	26	45	56	2
17 „	49	17	15	20	40	22	50	48	1
18 „	57	14	18	26	49	11	44	49	4
19 „	57	15	23	22	51	14	42	49	6
20 „	68	17	28	17	54	16	44	41	9
21 „	66	16	32	15	53	16	43	40	9
22 „	53	17	29	17	55	16	41	40	10
23 „	54	16	29	20	52	15	37	37	9
Sums ...	1,292	440	582	509	1,039	487	941	928	173
Per cent.	20·2	6·9	9·1	8·0	16·3	7·6	14·7	14·5	2·7

TABLE B.—*concluded.*

NOVEMBER.

Civil hours.	Winds recorded. N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid.)	118	18	12	2	5	10	30	48	6
1 „	125	20	10	3	6	12	31	47	6
2 „	125	15	11	4	5	11	29	48	6
3 „	128	13	10	3	4	10	28	43	6
4 „	122	13	11	1	5	9	27	46	4
5 „	111	18	7	3	4	13	30	44	4
6 „	128	17	9	4	5	15	30	51	1
7 „	120	23	11	6	3	14	25	57	1
8 „	124	25	15	5	5	6	21	53	...
9 „	117	31	16	2	6	8	21	55	...
10 „	114	37	15	5	2	9	30	50	...
11 „	107	35	18	4	4	8	35	47	...
12 (noon)	106	31	14	9	2	9	32	56	...
13 „	92	31	13	4	8	11	31	65	...
14 „	93	22	12	7	7	10	31	70	...
15 „	85	20	11	8	3	13	32	83	...
16 „	81	22	10	10	5	15	27	87	...
17 „	89	21	14	10	9	11	33	74	...
18 „	86	21	21	7	9	14	32	71	...
19 „	85	18	19	5	13	15	33	70	2
20 „	84	19	20	5	12	14	33	69	3
21 „	84	18	21	6	12	15	36	64	4
22 „	87	16	19	7	11	15	33	61	4
23 „	88	17	17	6	10	16	31	62	4
Sums ...	2,499	521	336	126	155	283	736	1,421	51
Per cent....	40·8	8·5	5·5	2·1	2·5	4·6	12·0	23·2	0·8

DECEMBER.

Civil hours.	Winds recorded. N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
24 (Mid.)	113	10	7	...	18	10	32	64	8
1 „	117	13	8	...	16	13	33	61	6
2 „	116	11	5	...	18	12	32	65	7
3 „	108	12	5	1	16	13	31	64	4
4 „	117	9	7	1	15	9	31	61	3
5 „	103	11	6	...	17	11	32	60	2
6 „	121	16	4	...	20	12	36	59	2
7 „	117	18	8	1	13	12	38	61	1
8 „	115	23	8	3	12	11	29	56	...
9 „	123	29	19	4	8	12	22	53	...
10 „	122	39	16	2	13	9	26	44	...
11 „	110	34	16	5	11	9	27	60	...
12 (noon)	102	20	13	4	9	10	34	78	...
13 „	91	14	6	4	9	7	47	93	...
14 „	92	17	4	1	7	11	42	94	...
15 „	84	14	4	3	5	11	45	102	...
16 „	103	8	2	3	5	11	45	87	...
17 „	100	11	5	4	7	11	39	88	...
18 „	108	14	6	4	10	13	39	75	1
19 „	109	15	5	5	10	13	39	73	2
20 „	113	16	5	3	14	9	38	69	4
21 „	119	14	5	3	15	8	38	63	5
22 „	118	11	4	4	15	7	35	65	4
23 „	113	14	6	3	16	9	33	64	4
Sums ...	2,380	399	173	58	299	262	846	1,658	53
Per cent....	38·8	6·5	2·8	0·9	4·9	4·3	13·8	27·1	0·9

TABLE C.

Mean co-ordinates of the wind's movement in each hour of each month at Calcutta, as registered by the Secchi anemograph from July 1871 to June 1875.

	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.	N.	E.
Mid to 1 ...	+0·30	−0·11	−0·30	−0·63	−2·04	−0·97	−4·51	−0·13	−4·61	−0·13	−2·76	+0·93	−2·15	+1·15	−1·13	+1·22	−1·03	+0·99	+0·74	+0·91	+0·94	−0·13	+1·08	−0·07
1 ,, 2 ...	+0·15	...	−0·14	−0·10	−2·73	−0·92	−4·12	−0·04	−4·23	−0·76	−2·07	+1·13	−2·03	+1·02	−1·05	+1·20	−0·81	+0·05	+0·82	+0·88	+0·95	−0·17	+1·10	...
2 ,, 3 ...	+0·09	...	+0·11	−0·50	−2·21	−0·89	−4·05	−0·07	−3·81	−0·12	−2·53	+1·04	−1·79	+0·91	−0·92	+1·23	−0·80	+1·08	+0·89	+0·80	+1·15	−0·10	+1·23	+0·01
3 ,, 4 ...	+0·60	+0·03	+0·22	−0·15	−1·79	−0·91	−3·94	−0·10	−3·18	−0·19	−2·50	+1·14	−1·84	+0·81	−0·77	+1·29	−0·63	+0·90	+0·97	+0·85	+1·30	−0·12	+1·22	−0·01
4 ,, 5 ...	+0·53	+0·04	+0·10	−0·21	−1·61	−0·64	−3·07	−0·10	−3·14	−0·34	−2·32	+1·03	−1·62	+0·93	−0·84	+1·30	−0·74	+0·78	+0·89	+0·80	+1·31	−0·04	+1·12	+0·04
5 ,, 6 ..	+0·59	+0·05	+0·39	−0·30	−1·37	−0·58	−3·74	+0·07	−2·74	−0·33	−2·02	+1·25	−1·67	+1·18	−0·75	+1·30	−0·90	+1·15	+0·95	+0·97	+1·33	−0·01	+1·00	+0·04
6 ,, 7 ..	+0·51	−0·07	+0·57	−0·33	−1·25	−0·74	−4·52	−0·24	−3·37	−1·10	−3·37	+1·09	−1·70	+1·51	−0·67	+1·78	−1·16	+1·11	+1·20	+0·92	+1·16	+0·12	+1·05	−0·03
7 ,, 8 ...	+0·67	−0·02	+0·08	−0·17	−2·00	−1·04	−5·73	−1·15	−4·58	−1·60	−4·17	+0·55	−1·92	+1·71	−0·95	+2·37	−1·68	+1·82	+1·49	+0·90	+2·00	+0·20	+1·20	−0·03
8 ,, 9 ...	+1·03	−0·04	+0·72	−0·10	−2·53	−1·56	−6·22	−2·14	−5·38	−2·75	−4·88	+0·58	−2·37	+1·18	−0·90	+2·75	−2·09	+2·00	+1·87	+1·37	+2·62	+0·29	+1·85	−0·01
9 ,, 10 ...	+1·29	+0·15	+0·76	−0·28	−2·30	−1·75	−6·30	−2·62	−5·78	−2·80	−4·85	+0·53	−2·00	+1·59	−1·15	+2·67	−2·03	+2·05	+2·06	+1·51	+2·93	+0·31	+2·63	−0·06
10 ,, 11 ...	+1·07	+0·09	+0·02	−0·79	−2·57	−1·78	−6·39	−2·73	−5·70	−3·12	−4·85	−0·10	−2·54	+1·83	−1·41	+2·73	−1·95	+1·96	+2·07	+1·67	+3·02	+0·20	+3·20	+0·02
11 ,, noon	+1·14	−0·12	+0·07	−0·69	−2·57	−2·10	−6·24	−2·45	−5·74	−2·91	−4·20	+0·85	−2·61	+1·67	−1·62	+2·55	−1·77	+1·86	+2·15	+1·70	+3·10	+0·15	+3·27	+0·02
noon ,, 13 ...	+1·34	−0·84	+0·63	−1·90	−2·27	−2·70	−6·24	−1·41	−5·17	−3·21	−5·02	+0·60	−3·24	+1·21	−2·08	+2·51	−2·93	+1·53	+2·00	+1·19	+3·34	+0·10	+2·80	−0·10
13 ,, 14 ...	+1·00	−1·15	+0·77	−1·90	−2·29	−2·91	−6·48	−1·70	−5·79	−3·28	−5·59	+0·88	−3·17	+1·14	−2·25	+2·78	−2·90	+1·80	+1·93	+0·72	+3·33	−0·07	+2·83	−0·12
14 ,, 15 ...	+0·83	−1·10	+0·38	−1·90	−2·55	−2·69	−6·57	−1·50	−6·53	−3·22	−6·17	+0·87	−3·79	+1·81	−2·54	+2·19	−3·01	+1·69	+1·90	+0·51	+3·21	−0·01	+2·08	−0·55
15 ,, 16 ...	+0·74	−0·99	+0·13	−1·87	−2·94	−2·58	−7·15	−0·95	−7·25	−2·15	−5·56	+0·97	−3·94	+1·59	−2·93	+2·33	−3·12	+1·75	+1·10	+1·05	+2·89	...	+2·55	−0·15
16 ,, 17 ...	+0·18	−0·37	−0·15	−1·30	−3·58	−1·64	−7·73	−1·04	−7·29	−2·07	−5·29	+1·04	−4·31	+1·43	−2·15	+2·02	−2·83	+1·39	+0·95	+1·19	+1·83	+0·07	+1·66	−0·29
17 ,, 18 ...	+0·05	−0·15	−0·61	−0·55	−4·02	−0·99	−6·88	−0·51	−6·45	−1·30	−4·70	+1·19	−3·12	+1·02	−1·95	+1·60	−2·20	+1·17	+0·12	+1·12	+0·82	+0·01	+0·93	−0·06
18 ,, 19 ...	−0·11	−0·09	−1·03	−0·28	−4·30	−0·90	−7·25	+0·45	−6·15	−0·61	−4·19	+1·02	−3·22	+0·93	−1·95	+1·19	−2·11	+1·30	+0·33	+0·89	+0·60	−0·03	+0·08	−0·04
19 ,, 20 ...	−0·15	−0·09	−1·20	−0·13	−4·03	−0·98	−6·95	+0·15	−5·39	−0·75	−4·20	+1·07	−2·93	+0·81	−1·87	+1·34	−2·09	+1·07	+0·33	+1·03	+0·61	−0·09	+0·59	+0·01
20 ,, 21 ...	−0·15	−0·30	−1·05	−0·16	−4·01	−0·92	−6·16	−0·01	−5·38	−0·55	−3·84	+1·25	−2·78	+0·98	−1·38	+1·77	−1·82	+1·10	+0·33	+1·14	+0·64	−0·04	+0·59	+0·01
21 ,, 22 ...	−0·13	−0·10	−0·94	−0·10	−4·72	−0·97	−5·79	−0·17	−5·33	+0·25	−3·24	+1·11	−2·85	+1·12	−1·23	+1·80	−1·67	+1·17	+0·44	+1·16	+0·61	−0·01	+0·64	+0·01
22 ,, 23 ...	−0·14	−0·38	−0·84	−0·59	−4·31	−0·89	−5·28	−0·11	−4·02	+0·29	−3·16	+1·20	−2·65	+1·18	−1·12	+1·72	−1·43	+0·99	+0·16	+0·04	+0·64	+0·05	+0·82	+0·00
23 ,, Mid.	+0·00	−0·15	−0·71	−0·53	−3·69	−0·77	−5·00	−0·09	−4·73	+0·13	−2·94	+1·10	−2·33	+1·11	−1·12	+1·49	−1·28	+0·87	+0·58	+0·85	+0·72	−0·03	+1·00	−0·02
Sums daily	+12·60	−6·39	+0·69	−17·32	−60·94	−32·88	−130·01	−19·13	−122·59	−33·50	−96·00	+23·09	−63·00	+30·72	−35·06	+45·88	−42·97	+32·60	+27·63	+25·16	+41·11	+0·02	+37·00	−2·19

N and E are treated as positive, S and W as negative values.

TABLE D.

Hourly co-ordinates of the mean diurnal variation of wind movement at Calcutta from the 4 years' registers of a Secchi Anemometer. East and North are designated by +, South and West by — signs.

Hours.	N. & S. Components.		E. & W. Components.		Hours.	N. & S. Components.		E. & W. Components.	
	Observed.	Computed.	Observed.	Computed.		Observed.	Computed.	Observed.	Computed.
	Mile.	Mile.	Mile.	Mile.		Mile.	Mile.	Mile.	Mile.
Mid to 1	+ 0·189	+ 0·1615	+ 0·094	+ 0·1298	Noon to 13	+ 0·152	+ 0·2286	— 0·102	— 0·3630
1 „ 2	+ 0·352	+ 0·3636	+ 0·074	+ 0·0508	13 „ 14	— 0·023	— 0·0091	— 0·194	— 0·4742
2 „ 3	+ 0·600	+ 0·5568	+ 0·088	+ 0·0337	14 „ 15	— 0·290	— 0·3142	— 0·179	— 0·4615
3 „ 4	+ 0·680	+ 0·7116	+ 0·072	+ 0·0957	15 „ 16	— 0·539	— 0·5890	— 0·300	— 0·3168
4 „ 5	+ 0·724	+ 0·7761	+ 0·130	+ 0·1832	16 „ 17	— 0·810	— 0·7652	— 0·083	— 0·1031
5 „ 6	+ 0·751	+ 0·7135	+ 0·238	+ 0·2193	17 „ 18	— 0·791	— 0·8410	+ 0·016	+ 0·0711
6 „ 7	+ 0·607	+ 0·5416	+ 0·193	+ 0·1722	18 „ 19	— 0·864	— 0·8303	+ 0·185	+ 0·1490
7 „ 8	+ 0·307	+ 0·3526	+ 0·112	+ 0·0776	19 „ 20	— 0·772	— 0·7582	+ 0·009	+ 0·1500
8 „ 9	+ 0·191	+ 0·2352	— 0·019	— 0·0016	20 „ 21	— 0·587	— 0·6333	+ 0·164	+ 0·1577
9 „ 10	+ 0·267	+ 0·2341	— 0·066	— 0·0518	21 „ 22	— 0·466	— 0·4611	+ 0·242	+ 0·1879
10 „ 11	+ 0·291	+ 0·3009	— 0·127	— 0·1101	22 „ 23	— 0·276	— 0·2576	+ 0·205	+ 0·2197
11 „ noon	+ 0·400	+ 0·3286	— 0·138	— 0·2160	23 „ Mid	— 0·068	— 0·0156	+ 0·189	+ 0·2034

EXPLANATION OF THE PLATES.

PLATE I,—Fig. 1: Annual variation of the mean diurnal resultant of the wind's movement. Fig. 2: Annual variation of the mean total wind movement per diem irrespective of direction. Fig. 3: Annual variation of the mean monthly temperature. Fig. 4: Mean diurnal variation of the wind after abstraction of the mean resultant. A line drawn from any point of the curve to the centre *A* represents in length and direction that movement which, compounded with the mean diurnal resultant, will give the actual mean movement for the hour preceding that denoted by the hour-number for that point of the curve. Fig. 5: The same corrected by Bessel's interpolation formula. The oval dotted line represents the variation of single period computed from the terms depending on $n\,\theta$ of the rectangular co-ordinates; and the line D E (the axis of this curve) represents the approximate direction of the land and sea breeze. Fig. 6: Variation of the east and west co-ordinates of Fig. 5. Fig. 7: Variation of the north and south co-ordinates of Fig. 5. All the above have reference to Calcutta.

PLATE II,—Fig. 1: Curve of the mean diurnal variation of vapour tension at Calcutta. Fig. 2: Curve of the mean diurnal variation of the weight (in grains) of water vapour per cubic foot of air at Calcutta. Fig. 3: Mean diurnal variation of the hourly wind movement irrespective of direction at Calcutta. Fig. 4: Mean diurnal variation of the air temperature at Calcutta. Fig. 5: Mean diurnal variation of pressure at Yarkand from nine months' observations, *viz.*, November to July inclusive. Fig. 6: Mean diurnal variation of pressure for the Tropical Atlantic [Square 3, Northern Half]. Fig. 7: Mean diurnal variation of pressure for Calcutta. Mean of the year. Fig. 8: Mean diurnal variation of pressure for Lucknow. Mean of the year. Fig. 9: Mean diurnal variation of pressure for Calcutta in March. Fig. 10: Mean diurnal variation of pressure for Calcutta in July.

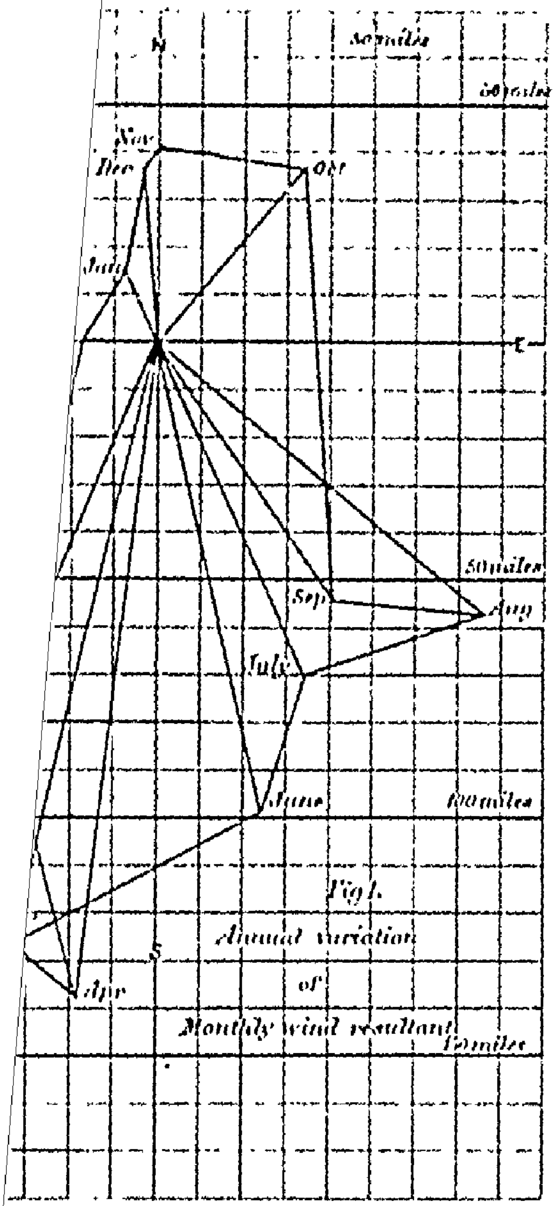
PLATES III AND IV.—The figures illustrate the mean diurnal variation of the wind at Calcutta in each month of the year. A line drawn from any point of the curve to the zero point on the margin shews by its length and direction the mean movement of the wind during the hour preceding that denoted by the hour-number on that point of the curve. The line drawn to this zero point from the centre of the curve shews in like manner the mean diurnal resultant. These curves are drawn from the reduced observations not corrected by the interpolation formula.

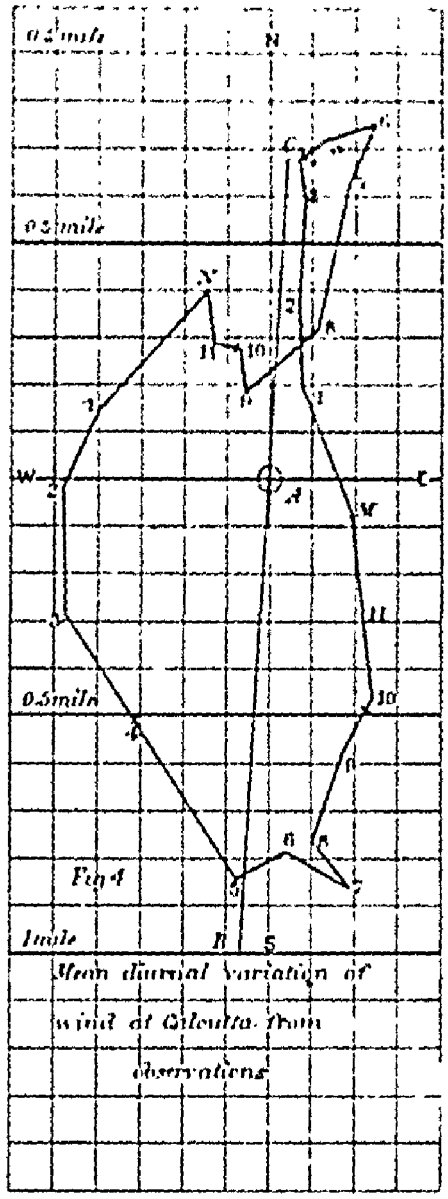
PLATE V.—Curves shewing the mean diurnal variation of the total wind movement in each month, irrespective of direction. The measurements of the ordinates are indicated on the margin, the initial letter of the month being appended to indicate the curves to which the figures severally refer.

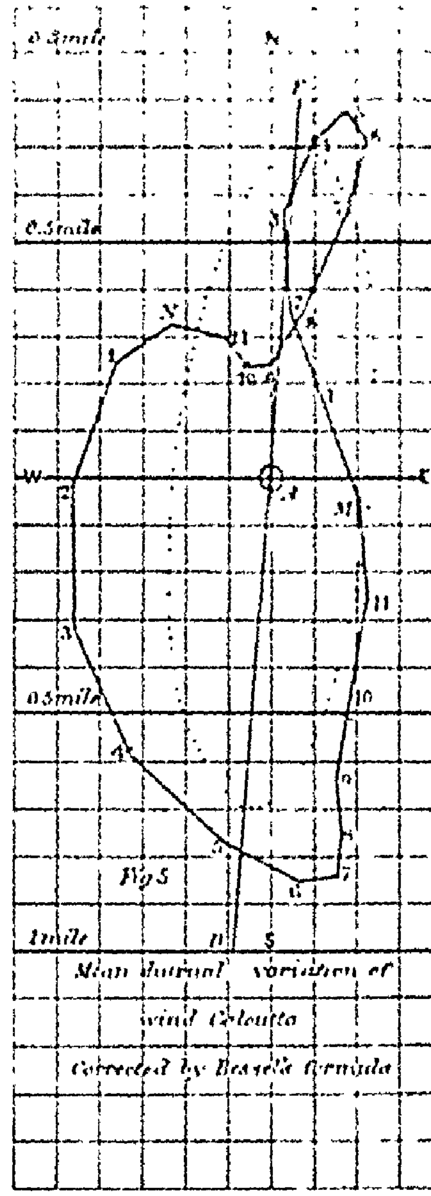
PLATE VI,—Figs. 1 to 12 represent graphically the mean pressure corresponding to each wind direction (after eliminating the normal diurnal variation of pressure) in each month at Calcutta. The inner circle represents the lowest pressure in Table IV for the month, and each succeeding circle an increment of 0·02 inch. Fig. 13 is the

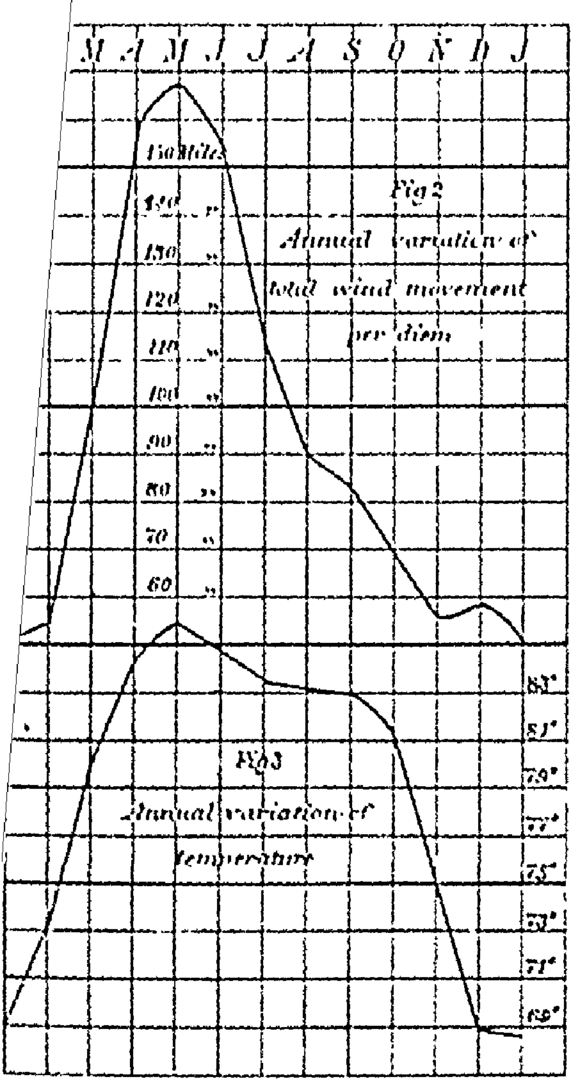
baric wind-rose for the whole year, represented on a similar scale. Fig. 14: The thermal wind-rose for the year, the inner circle representing the lowest temperature in the last line of Table III, and each succeeding circle an increment of 1° Fahr. Figs. 15 to 18 are the thermal wind-roses for January to April similarly represented.

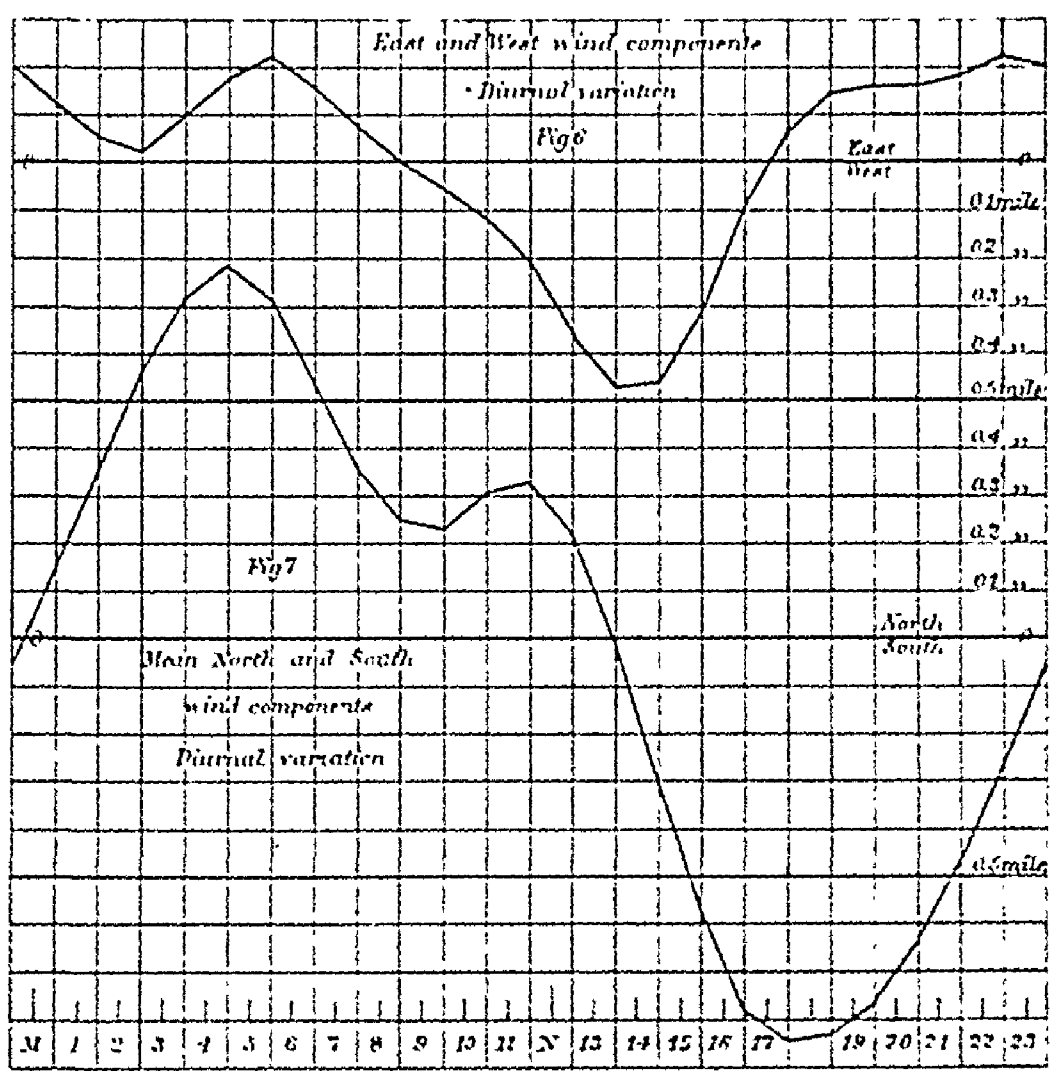
PLATE VII.—Figs. 1 to 8 are the thermal wind-roses for the months May to December on the same scale as Figs. 14 to 18 of Plate VI. Fig. 9: Hyetic wind-rose for the year at Calcutta, shewing the absolute frequency of rain from each quarter. Each circle represents an increment of 2 per cent. of the sum of all the rainfalls tabulated under 8 wind points. Figs. 10-12 illustrate, for each of the three Indian seasons, the probability of rain, when the wind is blowing from any given quarter, as a percentage of the whole number of winds from that direction. The numerical values are taken from Table VII.


N
50 miles
Nov
Dec
Oct
Jan
E
50 miles
Sep
Aug
July
June
100 miles
Fig 1.
Annual variation
of
Monthly wind resultant
S
Apr


0.2 mile
N
0.2 mile
W
E
A
0.5 mile
Fig 4
1 mile
S
Mean diurnal variation of
wind at Calcutta from
observations


0.5 mile
N
0.5 mile
W
E
0.5 mile
Fig 5
1 mile
S
Mean diurnal variation of
wind Calcutta
Corrected by Bessel's formula


M A M J J A S O N D J
150 Miles
Fig 2
Annual variation of
total wind movement
per diem
Fig 3
Annual variation of
temperature


East and West wind components
Diurnal variation
Fig 6
East
West
Fig 7
North
South
Mean North and South
wind components
Diurnal variation
M 1 2 3 4 5 6 7 8 9 10 11 N 13 14 15 16 17 18 19 20 21 22 23

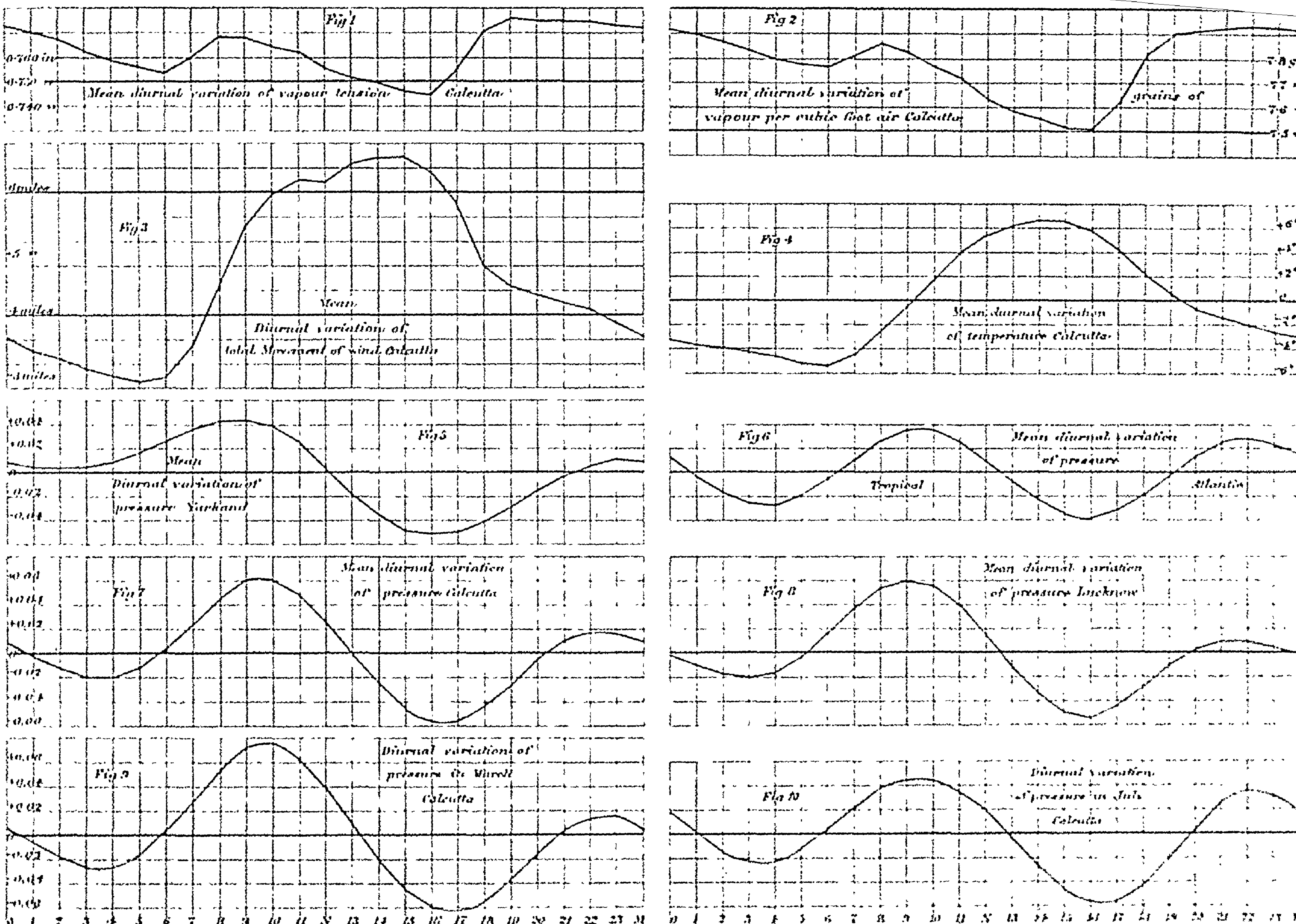
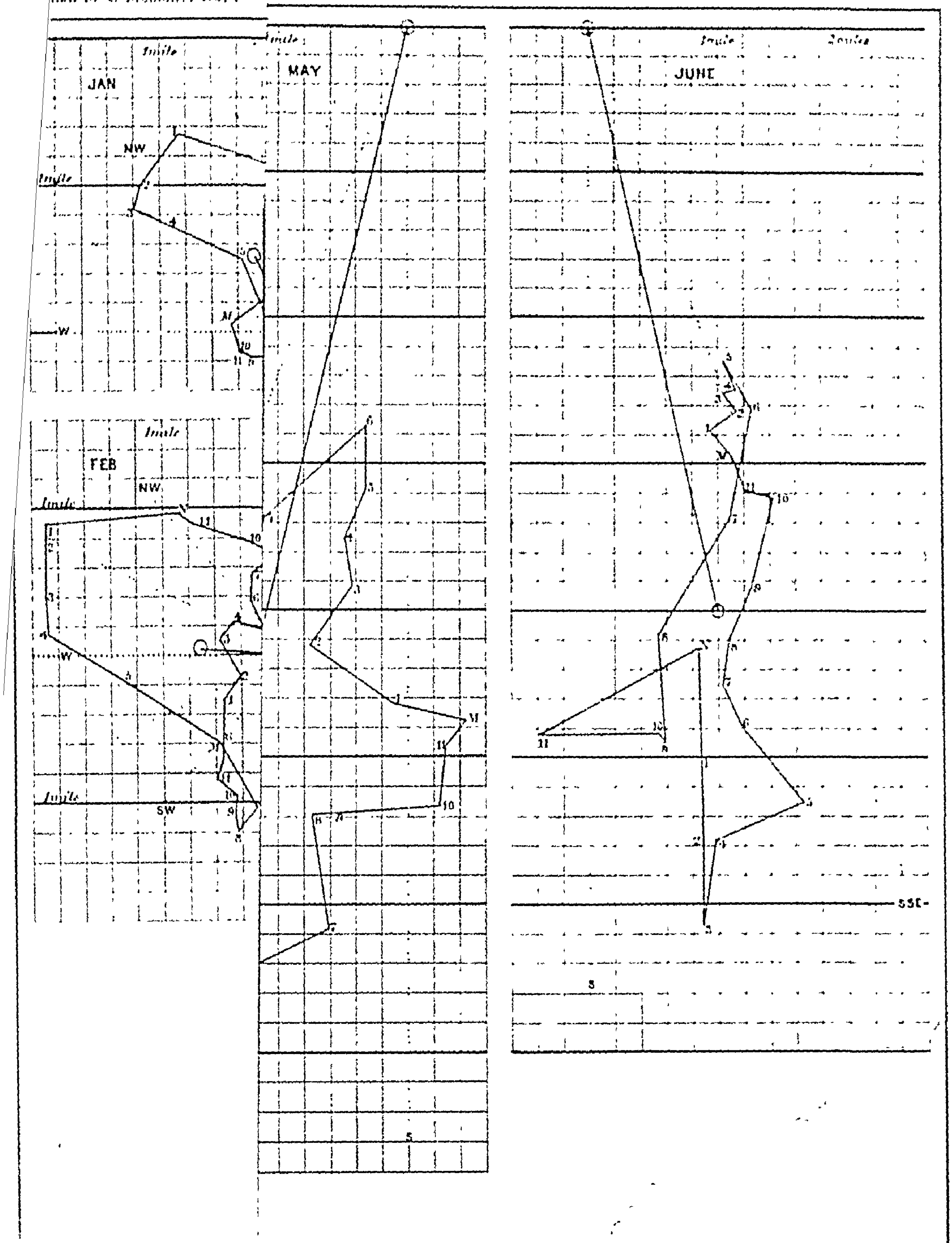
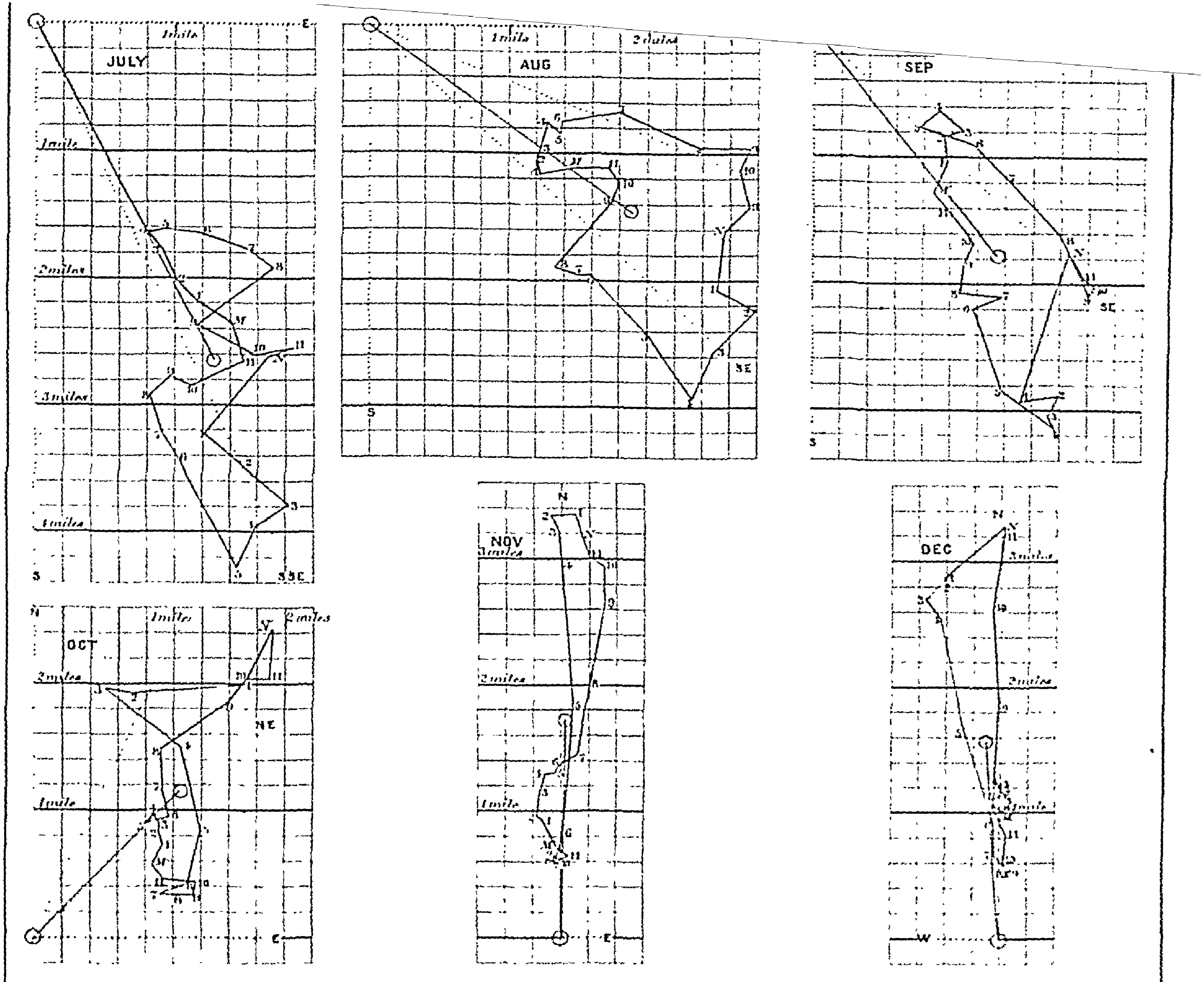
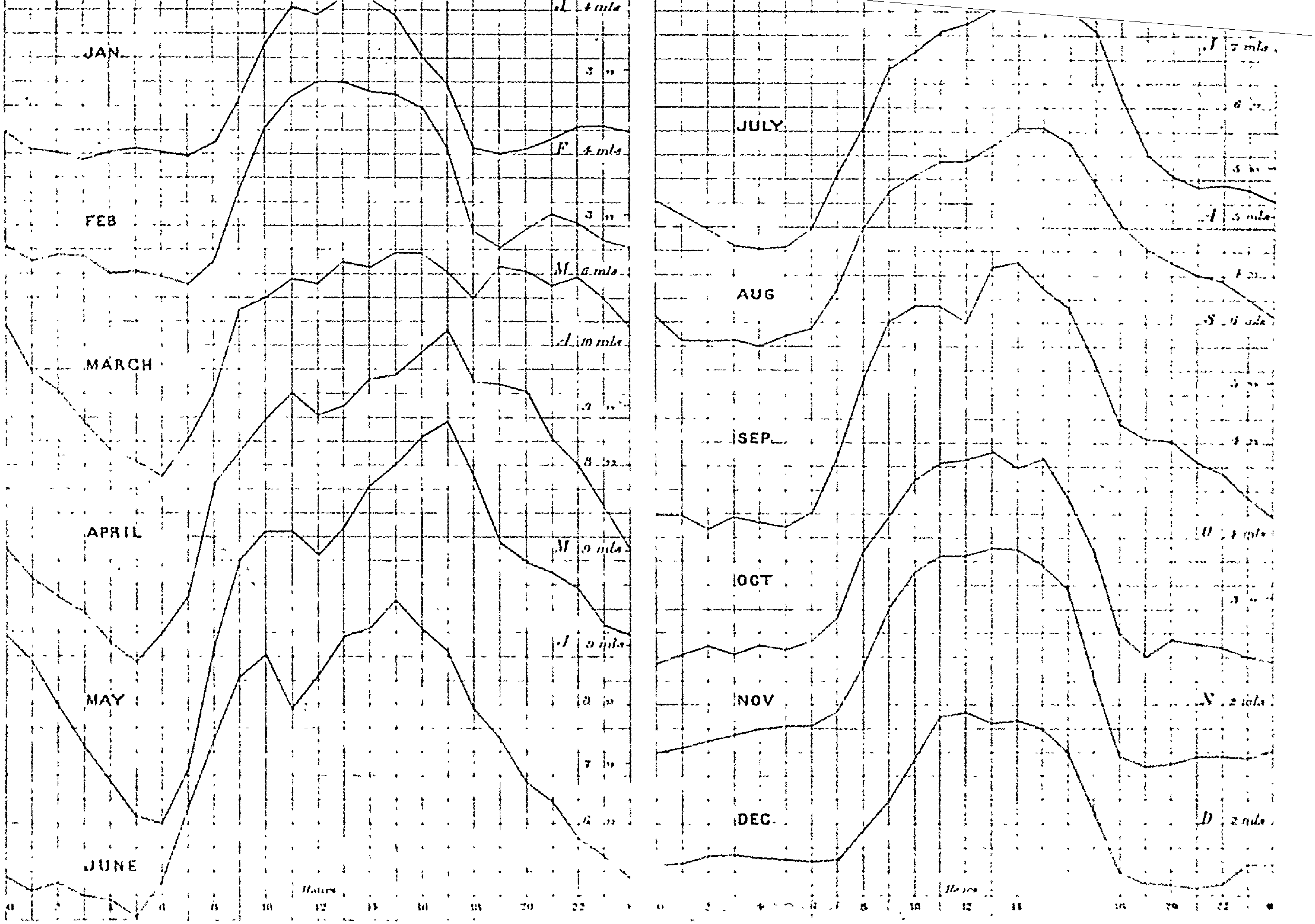


Fig 1
Mean diurnal variation of vapour tension Calcutta
Fig 2
Mean diurnal variation of vapour per cubic foot air Calcutta grains of
Fig 3
Mean
Diurnal variation of total Movement of wind Calcutta
Fig 4
Mean diurnal variation of temperature Calcutta
Fig 5
Mean
Diurnal variation of pressure Yarkand
Fig 6
Mean diurnal variation of pressure
Tropical
Atlantic
Fig 7
Mean diurnal variation of pressure Calcutta
Fig 8
Mean diurnal variation of pressure Lucknow
Fig 9
Diurnal variation of pressure
Calcutta
Fig 10
Diurnal variation of pressure in July
Calcutta

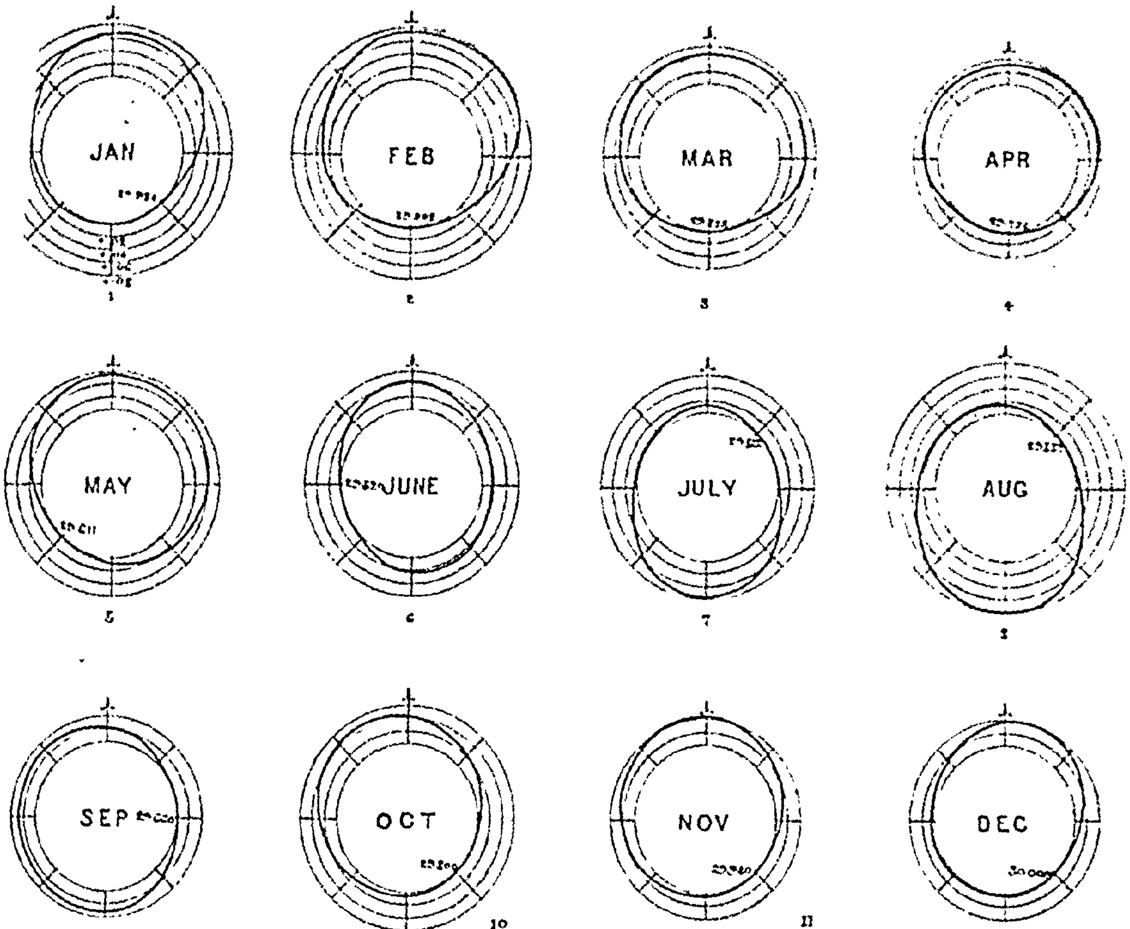

JAN
NW
W
FEB
NW
W
SW
MAY
JUNE
SSE



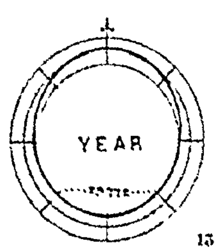
Lithographed at the Surveyor General's Office, Calcutta, July 18..



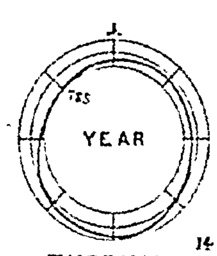
JAN
FEB
MARCH
APRIL
MAY
JUNE
JULY
AUG
SEP
OCT
NOV
DEC
Hours



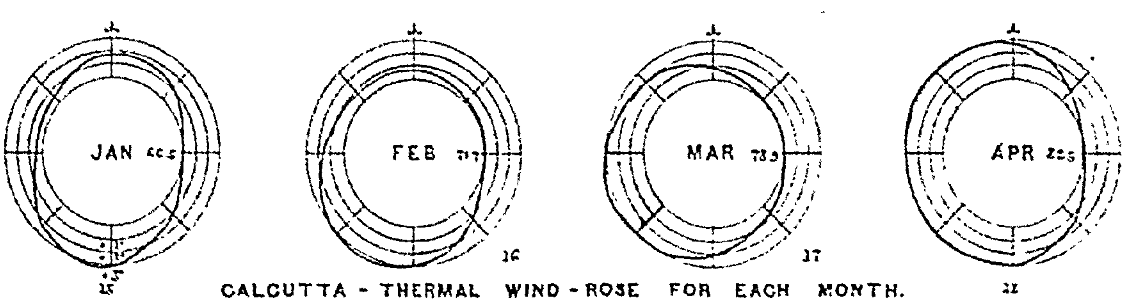
CALCUTTA - BAROMETRIC WIND-ROSE FOR EACH MONTH.



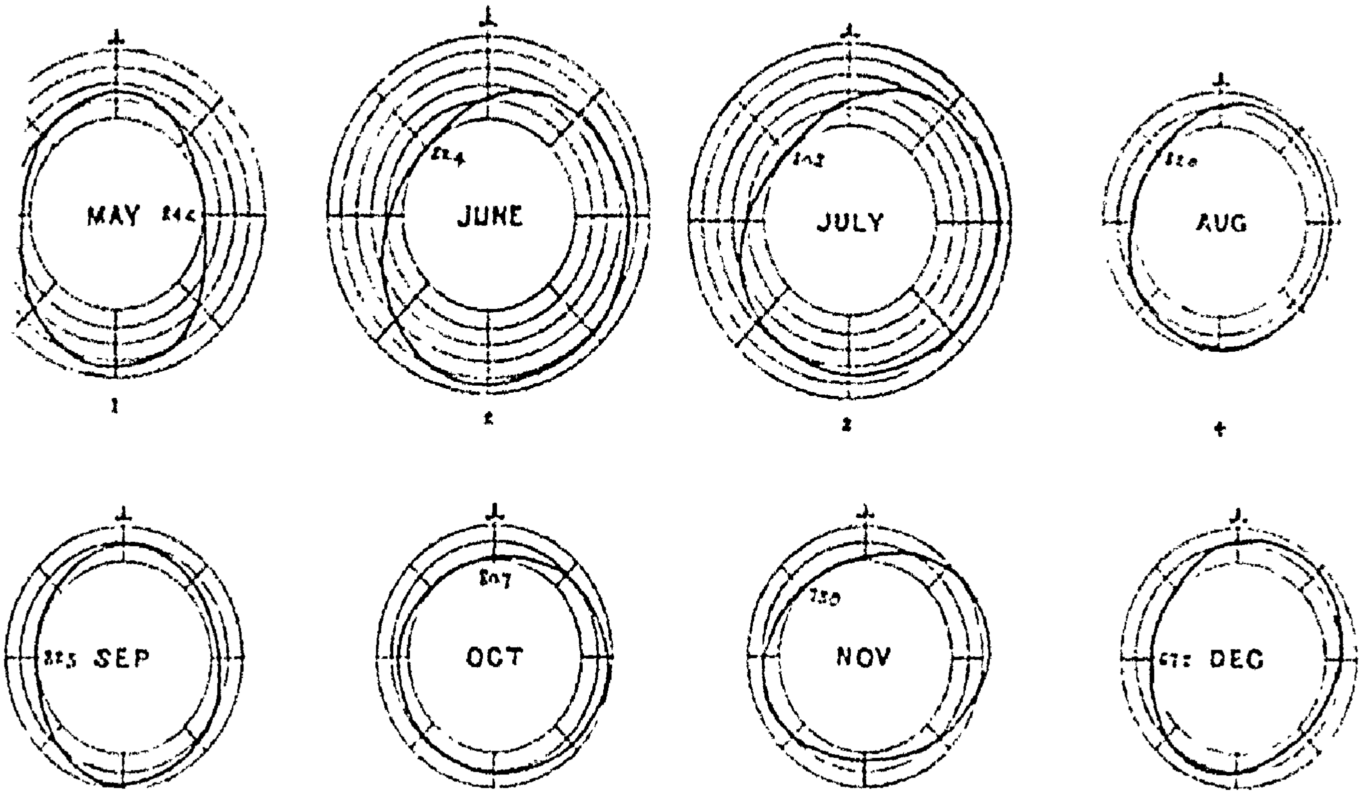
BAROMETRIC



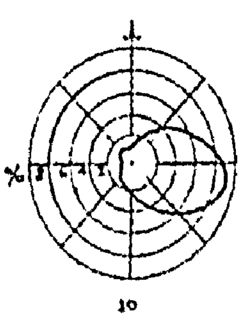
THERMAL



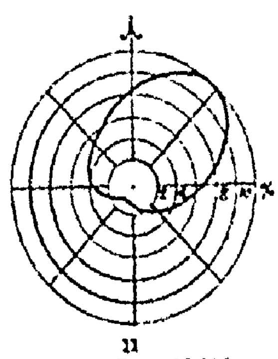
CALCUTTA - THERMAL WIND-ROSE FOR EACH MONTH.



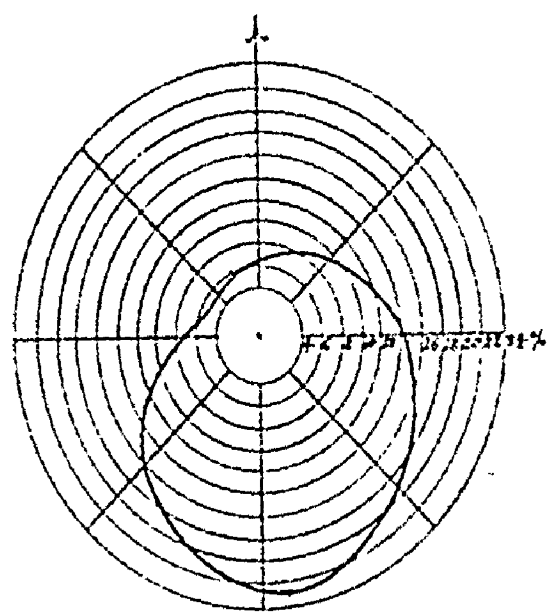
CALCUTTA - THERMAL WIND - ROSE FOR EACH MONTH



10
OCT TO FEB



11
MAR TO MAY



9
WIND ROSE OF
ABSOLUTE FREQUENCY OF RAINFALL
AT CALCUTTA.

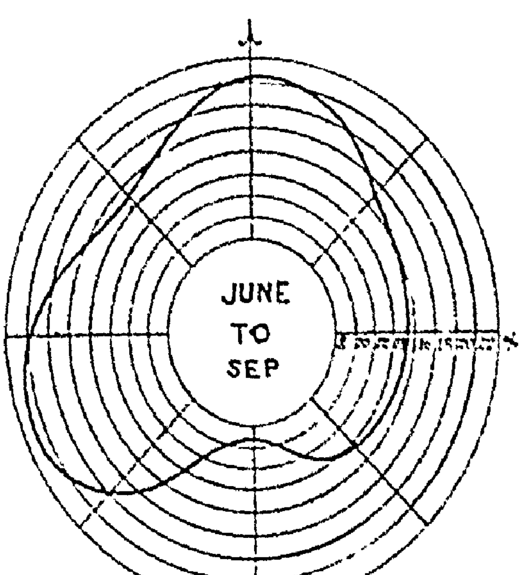


FIG 12

WIND ROSE OF
RAINFALL PROBABILITY WITH EACH WIND DIRECTION
AT CALCUTTA.

II.—*The Meteorology and Climate of Yárkand and Káshghár, being chiefly a discussion of registers kept by* Dr. J. Scully *in* 1874-5. *By* Henry F. Blanford, *Meteorological Reporter to the Government of India.*

The observations, which are more especially discussed in the following pages, are the work of Dr. J. Scully, of the Bengal Medical Service, who, in the autumn of 1874, accompanied the mission sent by the Indian Government to Káshghária under the charge of Mr. R. B. Shaw. This mission, to which Dr. Scully was attached as chief medical officer, reached Yárkand on the 6th October, and after five days' halt at that place, proceeded to Káshghár, where it remained till the 29th December. On that date the mission left to return to Yárkand, where it arrived on the 7th January 1875, and where it remained up to the 29th July of that year. During the whole period of the mission's residence at the above cities, observations were recorded regularly, night and day, at intervals of six hours, in addition to the readings of the self-registering thermometers for extreme shade temperatures and radiation; and, during the greater part of the time, of the anemometer. And on four days in each month, observations of the principal instruments were taken hourly, beginning and ending with a midnight observation. These observations alone afford, therefore, very excellent materials for a description of the meteorology of this remote and highly interesting country, during the whole of the winter, spring, and the greater portion of the summer months; and they are the more valuable, owing to the care with which they have been supervised throughout, and to the precautions that have been taken to eliminate all instrumental errors, and to reduce them to terms of acknowledged standards.

These, however, form only a part of Dr. Scully's contributions to meteorological science. During the arduous journeys to and from Yárkand, as well as on the shorter journeys between the above cities, no opportunity was lost of recording the readings of the instruments carried by the travellers; and on the return journey, special precautions were taken to ensure uniformity in the exposure of the thermometers, by the construction of a portable thermometer shed, which was erected at each halting place, and afforded conditions of exposure as nearly as possible identical with those which had been adopted throughout. At every halt of 24 hours or more, hourly observations were repeated; and data for the diurnal variation of all the meteorological elements ordinarily observed, have thus been furnished for seven places, at elevations of between 4,000 and 12,000 feet. A short series of observations was also recorded simultaneously at Káshghár and Yárkand for the purpose of ascertaining the difference of their elevation.

The result confirms that previously arrived at by Captain Trotter, and is further interesting as affording evidence of the remarkable uniformity of the meteorological conditions prevailing at these two places.

It will be easily understood that work so laborious and exact was not carried out successfully without somewhat special exertions. In the report which accompanies the first instalment of the registers,* Dr. Scully has briefly referred to the difficulties he met with in finding an additional man capable of being taught the work of an observer; and, after two failures, his eventual success in training Bhola, an uneducated hill cooly, first in the use of English numerals, then in that of decimal notation, and finally in the mode of reading the several instruments, and recording his observations in the newly acquired notation, is an achievement which reflects the highest credit on both teacher and pupil. I learn from Mr. Shaw that the walls of the mission quarters at Káshghár were, and probably still are, covered with Bhola's early essays in the art of English arithmetical notation.

Dr. Scully's registers, with the exception of the readings made during the journey, are herewith published in full, as reduced and corrected. In discussing the general features of the meteorology and climate of this part of Central Asia, I have also taken into consideration the careful, but less detailed, registers published by Captain Trotter and Dr. Bellew in the official report of Mr. (now Sir Douglas) Forsyth's mission in 1873-74; and the observations of Dr. Henderson, who accompanied Mr. Forsyth to Yárkand in 1870, and which were published *in extenso* in the work "From Lahore to Yárkand," of which he was author, jointly with Mr. A. O. Hume.

The following report from Dr. Scully, which accompanied the first instalment of his registers, describes the circumstances under which the meteorological work was carried on. The barometers used had been carefully verified to the Calcutta standard, before Dr. Scully's departure, by the late Mr. W. G. Willson, with whose advice and assistance the arrangements for the meteorological work of the expedition were made; and that which was returned (No. 910 Negretti and Zambra's) was re-compared in the Meteorological Office. The original and final comparisons gave results which differed only by ·012, the later readings being higher than the earlier. Some of the thermometers were furnished with corrections also; but as these were believed not to be in all cases trustworthy, the whole of the thermometers brought back by Dr. Scully were carefully re-tested at the freezing points, and compared through the range of observation with a Kew standard thermometer, No. 374, which I received in 1868 from Professor Balfour Stewart. The methods of reduction followed will be noticed subsequently.

* Given in full below.

Dr. Scully's *Report on the Meteorological Observations made at Káshghár and Yárkand from October 1874 up to the end of February 1875.*

"In forwarding the accompanying registers* of the meteorological observations made in Eastern Turkestan up to the present date, I wish to give a brief account of the system which has been followed, the instruments used, and the sites of the latter.

* Accompanying documents under four covers marked 1, 2, 3, 4, and containing meteorological registers for the period beginning 18th October 1874, and ending on the 28th February 1875.

"Observers.—The medical establishment of the Káshghár Agency consists of a hospital assistant and a compounder. At the suggestion of Mr. W. G. Willson, Officiating Meteorological Reporter to the Government of Bengal, meteorological allowances of Rs. 30 and Rs. 10 per mensem were sanctioned for these men, respectively, from the date of their arrival in this country.

"The hospital assistant, Sheik Ameer Bux, has a fair knowledge of English and writes a good hand; but when he joined me, I found that he had no knowledge whatever of meteorological instruments. On the journey to this country I had, therefore, to teach him the method of reading the various instruments, &c., and more especially the subject of decimal fractions, which he mastered after some time.

"No compounder was supplied to me before I left India, and after trying to teach two men picked up on the way and rejecting them as incompetent, I at last found a man intelligent enough for the purpose, and who is now compounder and second observer. This man, Bhola, a native of Kángra, was engaged by me at Leh to carry a barometer on the journey to this country. After our arrival at Káshghár I commenced to teach him first the figures, then decimal fractions, and finally how to set and read the various instruments; he is now a very painstaking observer.

"During the early portion of our residence at Káshghár I took my turn in making hourly observations, and I continue frequently to test the readings recorded by the observers. On the whole, I believe the observations now submitted to be worthy of credit, and I feel sure that no readings have been interpolated.

"Instruments.—Before leaving Calcutta, the following instruments were made over to me by the Mathemetical Instrument Department, *viz.*:—

Barometers. —3 Negretti and Zambra's, and 1 Aneroid.

Anemometers.—2 Casella's two-wheel instruments fitted with wind-vanes.

Hygrometers.—2 2 Sets of dry and wet bulb thermometers.

Thermometers.—Maximum, minimum, wet minimum, minimum terrestrial radiation and maximum solar radiation. All in duplicate.

Rain-gauges.—2 Symons'.

"The Aneroid was found to be constructed to read only up to 7,000 feet, and as it was, therefore, likely to get hopelessly out of gear in crossing the high regions on our journey (sometimes over 18,000 feet above sea level), it was returned from Srinuggur, and its place supplied by a Casella's boiling point apparatus. All the instruments above mentioned were carried into Eastern Turkestan without the slightest damage; a favourable result to be attributed to the fact of the articles having been carried all the way by porters, and to the great care shewn by hospital assistant Ameer Bux in looking after the instruments on the journey.

"It was intended to leave one of the mountain barometers at Leh, but a comparison of the readings of the barometer already at Leh with Negretti and Zambra's No. 911, showed the former to be in good working order; and its correction to the Calcutta standard, Newman's No. 86, was found to be only + 0·059. I therefore determined to take all the three barometers on with me, specially as I then learnt that Sir Douglas Forsyth's party had lost several instruments by breakage on the way to Káshghár.

"Barometer No. 911 was used on the journey, and for the regular observations at Káshghár and Yarkand up to the 22nd January, when it was accidentally knocked down, and, I regret to say, broken. Since that date, Barometer No. 910 has been in use; the corrections of these instruments have been regularly entered on Form A. The Torricellian vacuum of No. 911 was perfect up to the time when it was broken, and No. 910 is also in perfectly good condition.

"On proceeding from Yárkand to Káshghár, no Anemometer was taken on, as the Agency was expected to remain at the latter place for a few days only. Anemometer No. 265 was set up on the return of the Agency to Yárkand in January. The instrument (to which a wind-vane is fitted) is placed on the roof of my room twenty feet above the ground.

"The dry and wet bulb thermometers have been suspended in the thermometer shed four feet above the ground. Distilled water has been used for the wet bulb, and the muslin and wick frequently changed. During the very cold weather which we have had, the muslin was moistened with water about half an hour before the time of observation, and the reading of the instrument was then taken with the bulb covered by a film of ice. No corrections have been supplied for these instruments.*

"Tables of corrections for the maximum and minimum thermometers are the only ones which have been supplied. The *mean* error of the instrument with a contrary sign has been entered as the correction, because all the readings have been much lower than those given in the table drawn up at Calcutta. I should wish to be supplied with the corrections of all the thermometers determined in England, or if this is not possible, I beg that I may be furnished with a standard thermometer of an extensive range for determining the errors of the instruments.

"The rain-gauges have not been used, nor does there seem to be any likelihood of much rain in this country.

"*Sites of Instruments.*—The barometers have been placed in my room, suspended by means of their tripods and opposite a good light. For the adjustment of the vernier for night readings, the light of a lantern is directed on a sheet of white paper placed behind the instrument.

"The site of the anemometer has already been referred to. At Káshghár the force of the wind was estimated according to the table given at page 64 of the 'Instructions for Meteorological Observers.' Whenever the opportunity offers, the movement of the clouds at the zenith is observed by means of a looking glass and noted in the register.

"The sun rays thermometer is placed on two forked sticks, at a distance of about three feet from the ground. The minimum terrestrial radiation thermometer is placed on wool in the absence of grass. Both these thermometers are freely exposed, away from trees or walls.

"The hygrometers and other thermometers are suspended in a thatched shed, open on all sides. The bulbs of the thermometers are four feet from the ground and freely exposed to the air. The shed is in the centre of a large compound about 62 yards square. At Káshghár a similar shed was used for the thermometers, but the court-yard in which this was erected was smaller than the one here.

"*Hours of observation.*—Observations are recorded at 4 hours, 10 hours, 16 hours, and 22 hours daily, and on the 7th, 14th, 21st and 28th of every month hourly observations are made from midnight to midnight. When the latter readings are taken, each observer, during the night, reads the instruments for three hours; every third hour the two observers read together. The differences shewn in the hourly readings between the dry and wet bulb thermometers, and the dry and wet minimum thermometers, will, no doubt, be adjusted when the corrections are applied to the readings of the former instruments.

"Our watches have been corrected from time to time by observations of the sun's altitude at noon, made by Mr. Shaw, Political Agent at Káshghár, by means of a sextant.

* See next page.

6. "The latitude and longitude of Káshghár and Yárkand have no doubt been accurately fixed by Captain Trotter, and are probably already known in India. The accompanying registers will enable the heights of these places to be calculated. From a comparison of some simultaneous observations made at Leh and in this country, I have concluded that the height of Káshghár is 4,124 feet above sea level, and that of Yarkand 4,015.* To determine the difference in level between the two stations, I sent the compounder Bhola, while we were at Káshghár, to take readings at Yárkand. Sixty† simultaneous observations of the barometric pressure were thus obtained, which shew clearly, I think, that the atmospheric waves then affecting Káshghár and Yárkand were identical. The mean difference of the barometric readings was 0,111, and I make the difference of level to be 109 feet‡, Káshghár being higher than Yárkand. A copy of the readings at Yárkand, uncorrected, is forwarded herewith. The tables supplied to me with the instruments for reducing the barometric readings to 32° were not sufficiently extended for the low temperatures we have had here. In such cases the corrections have been made by means of the tables given in Sir Henry James' instructions."§ .

In the tabulated registers given in the Appendix, the barometric readings have been reduced to 32° Fahrenheit by the Royal Society's tables, and corrected to the Newman's standard at the Surveyor General's Office in Calcutta (No. 86), which has been found by an indirect comparison‖ to read ·011 in. higher than the standard of the Kew Observatory. The mean of the four observations recorded at 4 and 10 A. M. and P. M., is given in the column of daily means as representing the mean pressure of the day.

The readings of the thermometers for air temperature, above the freezing point, have in like manner been corrected to the corresponding values of the Kew standard thermometer No. 374, and those at and below the freezing point by the error of the instruments at that point, as determined by immersion in melting crushed ice, after Dr. Scully's return from Yárkand. The circumstances under which the thermometers were exposed have already been described in Dr. Scully's report. As in the case of the barometric observations, the mean of the four readings taken at 6-hour intervals is adopted as the mean of the day. The maximum thermometer is one constructed on Phillip's principle (with an interruption in the column produced by a small air bubble). The minimum thermometers were all spirit thermometers of the usual kind.

The thermometer for solar radiation is one made by Casella (also on Phillip's principle) and enclosed in a vacuum tube. When examined in Calcutta after Dr. Scully's return, it was found that the dividing air bubble had disappeared,¶ so that it no longer acted as a self-registering thermometer. I learn from Dr. Scully that it was in perfect working order up to his arrival at Murree on his return to India. As sun thermometers in vacuo differ very much in their readings, it is now the practice, in the Indian Meteorological Department, to compare them with an arbitrary standard of the same kind**

* See foot note, page 41.

† *i. e.*, Thirty at each station.—H. F. B.

‡ See foot note, page 41.

§ For these have been substituted values from a table specially computed for the Yárkand registers.—H. F. B.

‖ See Journal, As. Soc., Bengal, 1871, Vol. xl., Part 2, page 446.

¶ This is far from being an uncommon occurrence with these instruments. I have not been able to ascertain the cause satisfactorily.

** Casella's No. 9179, a Phillip's maximum mercurial in vacuo, having the small pea bulb, and one inch of the stem coated with matt-lamp-black.

(*i. e.* in vacuo), by exposing the instruments side by side to the sun under identical conditions. This has been done in the case of the Yárkand instruments, with the precaution, that the readings were taken only when the temperature marked by the standard was that of the moment of observation. The mean correction thus determined has been applied to all the readings in the registers.

The grass minimum thermometers used were spirit thermometers. One of them (in use up to the 15th April) was unfortunately broken, and as it had not been compared before the mission left India, the observations made therewith are necessarily uncorrected for any inherent error of the instrument. The remainder are corrected to the same standard as the air temperature observations.

The position of the anemometer, and its height above the ground (20 feet), have already been noticed in Dr. Scully's report. The instrument is a small one manufactured by Adie on Dr. Robinson's principle, with a vertical train of five wheels. The error of these instruments is always considerable, especially in light winds, such as appear to prevail almost exclusively in Káshghária; but there are, at present, no means of comparing anemometers at Calcutta, and the readings are, therefore, given uncorrected.

The temperatures of evaporation have been corrected to the same standard as those of the air, and the vapour tensions have been taken from a table especially computed for these registers by the formulæ—

$$x = f' - \frac{480\ (t-t')}{1240{\cdot}2 - t'}\ 25{\cdot}5$$

for wet bulb temperatures below the freezing point, and

$$x = f' - \frac{480\ (t-t')}{1130 - t'}\ 25{\cdot}5$$

for those above the freezing point.

I have preferred this, which is Regnault's modification of August's formula adapted to English units, to Apjohn's formula; inasmuch as comparative experiments made (chiefly, indeed, at high temperatures) in the dry atmosphere of the interior of India* shew that the mean value of the vapour tension thus obtained agrees very closely with that given by Regnault's hygrometer, when the dry and wet bulb hygrometer is exposed, as was the case in Yárkand, to the freely circulating air under a well thatched shed open all round. It is probable, indeed, that in so still an atmosphere as prevails in Káshghária, the results even thus computed are somewhat too high, but those obtained by Apjohn's formula are still more erroneous in the same direction. The table of vapour tensions used is that given by Guyot (hygrometric table VII) as based on the results of Regnault's determinations. The relative humidity has been computed from the same table. The last column in the vapour tension and humidity tables is computed from the readings of the self-registering dry and wet bulb minimum thermometers, placed four feet above the ground surface, under the thermometer shed.

* Journ. As. Soc., Bengal, Vol. xlv, Part 2, p. 53.

The cloud estimations are given in tenths of the whole expanse.

The rainfall was measured in a gauge of Symons' pattern placed on the ground.

In the three final columns are given Beaufort's initials (in italics) and cloud initials in capitals, *viz.*, C (cirrus) S (stratus) K (cumulus) and their compounds.

The cities of Káshghár and Yárkand are situated at the western extremity of the great elevated plain of Central Asia that lies between the Thian Shán on the north, and the Kuen Lun, the northern escarpment of Tibet, on the south. The greater part of this plain is believed to be a rainless waste, the desert of Gobi; but that part which fringes the mountains that surround it on the north-west and south, is rendered fertile by irrigation from the hill streams, and, as the present registers show, rain, if rare and scanty, is not altogether unknown. Yárkand is situated in latitude 38° 25′ north, and longitude 77° 16′ east; Káshghár in latitude 39° 24′ north, and longitude 76° 7′ east, the former at an elevation of 4,124 feet, the latter at 4,255 feet above mean sea level.*

The character of that part of the plain on which Káshghár and Yárkand are built, is described as follows by Dr. Bellew:—

"This (lowland) division comprises the belt of hill-skirt lying at the base of the bounding ranges, and varies in different localities. It is the most populous part of the country, and is the only portion of it which is permanently settled and cultivated. In it are situated all the cites and towns of the country, together with their respective suburban settlements.

* The latitudes and longitudes are those determined by Captain Trotter, R. E., (quoted to the nearest minute) and given in his report (Report of the Mission to Yárkand, 1873, pp. 305, 319, 332, 333). The elevations adopted in the text have been computed from Dr. Scully's observations during the nine months November 1874 to July 1875, and compared with those recorded during the same period at the Observatory of Leh in the Indus Valley. The elevation of this Observatory was determined by Captain Trotter to be 11,538 feet, by reference to points trigonometrically measured by the officers of the Great Trigonometrical Survey. The elevations of Káshghár and Yárkand given in the text are more than 200 feet in excess of those obtained by Captain Trotter, *viz.*, 4,043 feet and 3,923 feet, respectively, a difference which is no doubt partly due to an actual difference in the mean distribution of pressures in 1873-74 and 1874-75, but partly also, it is probable, to a difference in the treatment of the data. It is not stated in Captain Trotter's report what values were adopted for the mean temperature of the atmospheric column, the height of which is computed from the difference of pressures; and this is a matter of great importance, since, in dealing with stations so far apart, and differing so much in the range of the local temperature, no satisfactory result can be expected unless the irregularities arising from the mean diurnal variation can be eliminated.

My procedure has been to determine an approximate mean diurnal value for both pressure and temperature at both stations. In the case of Yárkand and Káshghár, this is given with sufficient approximation, in the registers, by the mean of the four sets of observations recorded daily at 4 and 10 A. M. and P. M. To obtain corresponding values for Leh, I have, in the case of pressure, assumed the mean of the readings at 10 A. M. and 4 P. M. as identical with that of the 24 hours; and, in the case of temperature, I have applied to the crude mean of the maximum and minimum readings and those recorded at 10 A. M. and 4 P. M., a correction obtained by multiplying the mean range by a factor, determined empirically from the Yárkand registers in the following manner:—

Let M m a and b represent the respective means of the maximum, minimum, 10 h. and 16 h. readings at Yárkand in any given month, and T the true mean temperature of that month; then,—

$$\rho = \frac{\frac{1}{4}(M + m + a + b) - T}{M - m}$$

where ρ is the factor required. This multiplied into the mean range of temperature $M' - m'$ at Leh in the same month, gives the correction to be applied to the mean of the corresponding readings M' m' a' b', at that station, to obtain the (approximately) true mean. This method, on a principle devised, I believe, by Mr. Pogson, is the best method of approximation practicable, whenever it

"In its general aspect this division partakes of the characters of the two others, between which it forms the connecting medium,—of the hills on one side and of the desert on the other. Near the former it presents an uneven surface, on which are prolonged the subsiding terminal offshoots of spurs from the mountain boundaries, till they merge into the general level of the plain: whilst, towards the latter, it rapidly expands into an undulating plain which insensibly sinks and becomes continuous with the desert.

"The soil everywhere is characterized by its aridity and barrenness. Contiguous to the hills, it consists of stony detritus, intermixed with rolled boulders; further off, it becomes coarse gravel, and finally, on the verge of the desert, it assumes the form of pure sand. Everywhere it is more or less highly charged with salines, which, in the depressions of the undulating surface, form sheets of white efflorescence, or spongy encrustations on which flourish a variety of saltworts. In many places these salines retain sufficient moisture to form mud bogs and marshes, on which grow coarse reeds and dwarf tamarisks.

"But the peculiar features of this tract are the numerous rivers which traverse its surface, to their point of ultimate junction with the main stream—the Tárim River—which is the great drainage channel for the whole country. They are the seats of the fixed population and the entire productive industry of the country. Their number and names are many, as they issue from the mountains on three sides of the basin; but they all converge, at different points, to form four principal rivers, which are named after the settlements founded upon them. They are the Khútan, Yárkand and Káshghár and Aksú Rivers; and they all converge and unite, far out on the desert to the south of Aksú, to form the Tárim River, which afterwards receives as tributaries the Kúchá and Kaidú Rivers, and thus completes the drainage of the valley.

"These streams, in their passage across this tract, mostly flow in wide channels between low banks of sand. The larger ones flow upon firm, pebbly bottoms, and the smaller ones in a bed of sand. The

may be assumed that the general form of the diurnal curve of variation is the same at the two stations, however different may be its amplitudes. Now this is the case at Leh and Yárkand, exception being made of such difference as arises from a difference of 4° of latitude, but this error cannot be large. The following table gives the data employed in the reduction of the heights:—

		Ká'shghá'r and Yá'rkand temperature.			φ	Leh temperature.				Káshghár and Yárkand barometer.	Leh barometer.	Difference in feet.	Káshghár and Yárkand elevation.
		T.	$\frac{M+m+a+b}{4}-T.$	$M-m.$		$M'-m'$	$\frac{M'+m'+a'+b'}{4}$	Corr.	T'.				
1874, Káshghár.	November ...	32·7	+ 4·85	21·7	− ·223	34·6	35·47	−7·71	27·8	26·100	19·750	7,282	4,256
	December ...	26 8	+ 2·78	24 0	− ·115	35·0	29·08	−3·31	25·7	25·995	19·730	7,145	4,493
1875, Yárkand.	January ...	20·0	+ 1·98	23·9	− ·084	30·3	23·28	−2·54	20·7	26·120	19·570	7,384	4,154
	February ...	30·0	+ 3·25	26 7	− ·121	25·6	26·25	−3·10	23·1	25·992	19·595	7,330	4,208
	March ...	50·7	+ 3·85	29 0	− ·133	27·4	37·85	−3·64	34·2	25·912	19·727	7,301	4,237
	April ...	64·1	+ 4·75	29 8	− ·159	29 3	47 75	−4 66	43·1	25·891	19·715	7,452	4,080
	May ...	69·4	+ 4·33	29 6	− ·146	25 6	49 25	−3·74	45·5	25·844	19·683	7,507	4,031
	June ...	75·8	+ 4·78	30 2	− ·158	28·4	58 72	−4·49	54·2	25·738	19·642	7,560	3,978
	July ...	81·7	+ 4·55	28·1	− ·162	27·6	66·10	−4·47	61·6	25·645	19·605	7,606	3,932

Thirty sets of observations recorded simultaneously at Yárkand and Káshghár, and divided into three sets of ten each, showed a mean difference of 130, 131 and 131 feet, respectively (mean 130·6 feet), which agrees nearly with Captain Trotter's determination of 137 feet. Káshghár is the higher. If, then, 131 feet be deducted from the November and December values for Káshghár, the mean of the residues and of the values obtained directly for Yárkand is 4,124 feet (the elevation of Yárkand adopted in the text). And, adding 131 feet, that of Káshghár is 4,255 feet

volume of their streams varies according to the season. Thus, in winter, even the largest of them are so much shrunk, as to be crossed dry-footed by stepping from stone to stone, whilst the smaller ones, which are mostly bridged, are at this season generally frozen over. In summer, on the contrary, they are all so much swollen by the melting snows, that they fill the whole of their wide channels; and, as in the case of the Yárkand River, form a stream nearly a mile broad and only passable by boat.

"None of these rivers is navigable, but they are otherwise profitably utilized for purposes of irrigation. Numerous canals are drawn off from them to the lands on each side, and thus convert considerable tracts of what would otherwise be desert waste into fertile and populous settlements. The extent of these is at present limited; but were the means existing fully developed, a much wider area might be settled and brought under cultivation.

* * * * *

"*Desert.*—This division occupies the whole of the Káshghár basin beyond the lowland belt skirting the mountains; and as the two insensibly merge, a line of demarcation is not easily recognized. In general aspect it presents a vast undulating plain of sand which slopes gently to the eastward. Its elevation is estimated to vary between 2,500 feet at Lob Nor and 4,000 feet on the Yárkand border. Its surface is traversed by the four rivers which go to form the Tárim, and by that stream itself. The banks of these rivers are fringed by broader or narrower belts of forest, composed mainly of poplar, willow and tamarisk, amongst which is an impenetrable growth of tall reeds. In the covert of these thickets lurk the tiger, leopard, lynx and wolf, together with the wild pig; and a species of stag, called *bocá* or *búghá* for the male, and *marál* for the female, pastures on their skirts.

"Further out in the desert towards the east, the high banks and sand dunes, which break the uniformity of its level towards the west and south, either disappear, or greatly diminish in height; and then the river spreads broadcast over the surface, forming wide lagoons or marshes, belted by reeds and tamarisk brushwood, till the waters again find a defined channel between banks. And this occurs, at intervals, over an extent of some three hundred miles; beyond which the river flows in a clear channel, five days' journey in length, to the Lake Lob.

"The greatest portion of this desert tract is an unmitigated waste, with a deep coating of loose pulverulent salines, on which only the wild camel finds a footing. Horses cannot traverse it, owing to their sinking knee-deep in the soft soil; whilst, to man, the dust raised proves suffocating, and the glare from the snow-white salts blinding."

One peculiar geological feature of the country may be specially mentioned here on account of its meteorological associations. This is the *loess*, which forms extensive deposits in the valleys on the borders of the mountain zone, and which is thus described by Dr. Stoliczka, the lamented naturalist and geologist who accompanied Mr. Forsyth's mission:—

"Among the sandy and clayey deposits I was not a little surprised to find true *loess*, as typical as it can anywhere be seen in the valleys of the Rhine or of the Danube. I might even speak of 'Berg' and 'Thal-Löss,' but I shall not enter into details on this occasion; for I may have a much better opportunity of studying this remarkable deposit. At present I will only notice that, commonly we meet with extensive deposits of *loess* only in the valleys. Its thickness varies, in places, from ten to eighty and more feet; a fine yellowish *unstratified* clay, occasionally with calcareous concretions and plant fragments. In Europe, the origin of this extensive deposit was, and is up to the present date, a disputed question. Naturally, if a geologist is not so fortunate as to travel beyond the 'Rhine' or 'Donau-thal,' and is accustomed to be surrounded with the verdant beauty of these valleys, he might propose half a

dozen theories, and as he advances in his experience, disprove the probability of one after the other, until his troubled mind is wearied of prosecuting the object further. Here, in the desert countries, where clouds of fertile dust replace those of beneficial vapour, where the atmosphere is hardly ever clear and free from sand, nay occasionally saturated with it, the explanation that the *loess is a sub-aerial deposit* is almost involuntarily pressed upon one's mind. I do not think that by this I am advancing a new idea, for—unless I am very much mistaken—it was my friend Baron Richthofen who came to a similar conclusion during his recent sojourn in Southern China."*

The haziness of the atmosphere, owing to the constant presence of fine dust, is a most characteristic feature of this region, and has been noticed by several of the travellers who have visited Káshghária of late years. Thus, Mr. Shaw writes†—

"I am forcibly struck by the contrast between this climate and India. For it is twelve miles from Kángra to the range of the outer Himálaya, and at Kángra they seem to overhang the town. Every gorge and every rock could be counted, one would think, so distinctly are the forms visible. But here, at a distance of twelve miles, the Pamir mountains appear to be a distant range, of which the outline only is distinguishable."

Dr. Henderson, in like manner, points a contrast between the atmosphere of Káshghária and that of Ladák in the following terms‡:—

"Perhaps the most striking feature of Ladák is the wonderful clearness of the atmosphere. This is partly owing to its extreme dryness and rarefaction; but chiefly to the entire absence of haze. On the Yárkand plains, with an atmosphere equally dry, we had a dense haze produced by fine dust floating in the air."

Further on he says§—

"From the day we entered the Kárákásh valley until our return, the air was filled with a dense haze, which limited the view so much, that, very often, hills five miles distant were barely visible, and it was difficult to get a good idea of the country through which we travelled."

And again‖—

"A haze filled the air the whole time we were in the country, and only at one or two points, *viz.*, between Bora and Sánjú, could we get a glimpse of the low hills to the south; and the higher ranges were never visible."

Dr. Bellew thus refers to the cause of this dust haze"¶—

"During the spring and summer months, a north or north-west wind prevails. It blows with considerable force and persistence for many days consecutively. As it sweeps over the plain, it raises the impalpable dust on its surface and obscures the air by a dense haze resembling in darkness a November fog."

* In that part of China that lies to the east of the Great Desert, the *loess* formation described by Baron Richthofen attains to a much greater thickness than in Yárkand, often considerably exceeding one thousand feet. It spreads alike over high and low ground, smoothing off the irregularities of the surface, and "it is owing in a great measure to its existence that Northern China differs much from Southern China, as regards scenery and products, the mode of agriculture, and the means of transportation." As mentioned by Dr. Stoliczka in the passage quoted in the text, Baron Von Richthofen ascribes its formation to the winds.

† High Tartary, Yárkand and Káshghár, page 234.

‡ Lahore to Yárkand, page 65.

§ *Ibid*, page 107.

‖ *Ibid*, page 133.

¶ Yárkand Report, 1873, page 27.

There are several other references to this phenomenon in the general description of the climate given in the official report on Mr. Forsyth's mission of 1873. There is not, perhaps, any ground for surprise that, in a country so characteristically dry, the air should be thus charged with a perpetual dust-haze; but it is to be observed that Káshghária presents, in this respect, a remarkable contrast to the Persian desert of Kirman, which is equally arid and rainless, but where the atmosphere is so clear that, as I am assured by my brother and Major St. John, the estimated distance of objects was frequently found by them to fall short of their real distance by more than one-half. Both regions are salt deserts, and it is an interesting question, whether there is any difference in the hygroscopic properties of the prevalent salts, which will tend to explain the contrast.

I shall now consider each of the principal elements of the meteorology, taking them in what may be regarded as their physical order of succession, *viz.*, 1st, *insolation and radiation*; 2nd, *temperature*; 3rd, *pressure*; 4th, *anemometry*; 5th, *hygrometry*, clouds and rainfall. In speaking of this as the physical succession of the phenomena, I do not, of course, desire to be understood that I regard this or any other order that may be named as expressing the exclusive sequence of cause and effect. But in tropical climates, and to a somewhat less extent in that of the region now under consideration, the sequence thus indicated is a real and important one, and is convenient for so marshalling the facts as to illustrate the interdependence of the leading elements of the local meteorology.

INSOLATION AND RADIATION.—Dr. Bellew remarks in his sketch of the climate of Káshghária in the official report of Mr. Forsyth's mission:*—

"The intensity of the sun's rays on the plains of Káshghár is a notable feature of its climate, and a phenomenon that requires explanation; because its effects upon the sensibility of man are out of all proportion more perceptible than on that of mercury. The highest temperature recorded during our stay in the country, from the 1st November to the 24th May, was 140° F. by a maximum thermometer placed in the direct rays of the sun; yet the exhaustion produced in man, by exposure to a sun which indicated considerably less than that degree by the thermometer, I observed was much greater than anything I had ever noticed in India. None of our camp-followers could walk a march even in an early sun, and our cattle exhibited more distress than is usual in India. The natives of the country, too, are equally prone to its effects, and cannot endure toil in the sun. It was a subject of common remark amongst us that, in all our marches, we rarely met a traveller on foot; and rarer still, if ever, saw one carrying a load. Every-body in the country rides, either on horse, camel, ox or ass, or he travels by cart. Judging from my personal experience, I am disposed to attribute this inordinate action of a by no means tropical sun, to the combined effects of a very dry atmosphere, and refraction of caloric, with blinding glare, from an arid soil of salines and sand."

Whatever may be the cause of the physiological effects referred to by Dr. Bellew, it is clear from the registers that, as measured by the difference of the sun thermometer in vacuo and the maximum air temperature, the average intensity of insolation

* Op. cit., page 64.

on the plains of Káshghária in 1875 was equal, or nearly so, to that of stations in the Upper Provinces of India 12 degrees nearer to the equator and in some months higher.

The observations at Káshghár in the last three months of 1874 show, indeed, a considerably lower intensity than those of Bareilly in the same months, a difference which may be due either to the greater athermancy of the atmosphere of Káshghár, as compared with Yárkand, or to the season of the year. It seems not improbable that the effect referred to by Dr. Bellew may be owing to the lower declination of the sun, which, with equal intensity of radiation, will have more effect on the surface of the body, especially the spinal region when the rays fall obliquely, than when the sun is vertical overhead. This is borne out by my own experience, when engaged in the Geological survey of the dry country around Trichinopoly, under the vertical sun of April. In my experience, the depressing effect was much greater between 8 and 10 A. M. than during the hour or two on either side of noon. The readings of all the sun thermometers on which the following comparative table is based have been corrected to one and the same standard by exposing them under similar conditions to the sun's rays.

Table showing the comparative intensity of solar radiation in Káshghária and the Gangetic Plains.

Month.	Kashghar and Yarkand, 1874-75.			Lucknow, 1874-75.			Bareilly, 1874-75.		
	Sun.	Max. air.	Diff.	Sun	Max. air.	Diff.	Sun.	Max. air.	Diff.
October	*101·1	57·1	44·0	?			151·1	90·8	60·3
November	97·4	47·6	49·8	?			1418·	82·3	59·5
December	86·3	40·4	45·9	?			130·4	73·7	56·7
January	93·3	32·4	60·1	?			127·0	71·3	55·7
February	102·9	?	?	138·2	79·5	58·7	133·9	74·2	59·7
March	121·2	?	?	154·9	96·8	58·1	152·7	92·4	60·3
April	†135·9	80·2	55·7	162·3	105·7	56·6	163·1	103·0	60·1
May	142·7	84·7	57·8	163·9	105·5	58·4	163·3	103·8	59·5
June	150·6	91·8	58·8	151·1	104·4	46·7	163·8	104·7	59·1
July	‡152·4	96·5	57·3	151·2	97·9	53·3	154·1	96·2	57·9

The highest sun temperature registered was 166°, on the 12th June; the excess over the maximum temperature of the air being 74·6°, which is also the highest in the registers. Up to the 28th July, readings exceeding 160° were recorded on ten days, and those from 155° to 160° on twenty days. The excess of the temperature of insolation over that of the air amounted to more than 70° on three days between the 6th April and the 28th July, and to between 65° and 70° on eight days.

As with the solar, so with terrestrial radiation. The dryness of the atmosphere favours the escape of heat in the night hours, as it favours the passage of the sun's heat to the ground in the day. On the average of the ten months, (October to July,) the

* Thirteen days only. † Twenty-five days only. ‡ Twenty-eight days only.

temperature of the thermometer (exposed on wool at night) marked a temperature 6° lower than the minimum temperature of the air 4 feet above the ground. This difference is nearly one-fourth greater than the average depression of similar instruments (on grass) observed at the two stations Lucknow and Bareilly in Upper India, in the corresponding months of past years, and the greatest average depression of any one month exceeds that of any single month at either of these stations. This is shown in the following table:—

Month.	Lucknow average.			Bareilly average.			Kashghar and Yarkand, 1874-75.			Lucknow, 1874-75.			Bareilly, 1874-75.		
	Grass radiation.	Minimum air.	Difference	Grass radiation.	Minimum air.	Difference.	Wool radiation.	Minimum air.	Difference.	Grass radiation.	Minimum air.	Difference.	Grass radiation.	Minimum air.	Difference.
October ...	58·5	65·0	6·5	60·3	64·7	4·4	26·2	32·1	5·9	60·3	64·4	4·1	59·1	65·6	6·5
November ...	45·7	51·7	6·0	44·2	51·8	7·6	16·2	21·7	5·5	44·7	48·6	3·9	42·2	50·3	8·1
December ...	40·0	45·0	5·0	41·8	45 7	3·9	11·5	16·1	4 6	39·2	43·6	4·4	37·9	44 9	7·0
January ...	43·4	45·4	2·0	41·5	44·1	2·6	0·8	9·8	9 0	39·3	43·2	2·9	38·8	45·3	6·5
February ...	46·1	51·2	5·1	45·8	51·1	5·3	10·9	17·2	6·3	46·7	50·1	3·4	45·8	50 3	4·5
March ...	52·2	59·7	7·5	51·9	58·7	6·8	31·7	36·2	4·5	54·9	60·1	5·2	54·8	60 9	6·1
April ...	62·9	69·6	6·7	61·0	67·8	6·8	45·0	50·4	5·4	65·4	73·3	7·9	63·1	71·6	8·5
May ...	72·3	79·0	6·7	73·5	76·5	3·0	47·9	54·7	6·8	71·1	77·6	6 5	71·8	76·6	4·8
June ...	79·6	83·4	3·8	76·8	80·7	3·9	54·9	61·6	6·7	78·5	83·3	4·8	78·3	81·6	3·3
July ...	78·7	80·4	1·7	77·1	78·5	1·4	63·4	68·4	5·0	76 9	80·9	4·0	77·3	79·9	2·6

The greatest depression of temperature by nocturnal radiation was in the month of January, on the average of which month it amounted to not less than 9° below that of the air. The greatest on any one day was 15°, *viz.*, on the 9th of that month, when the exposed thermometer sank to −4·0°. This was not, however, the lowest temperature reached. On the 31st January it registered −4·8; on the 30th −6·5; and on the 20th, the lowest recorded, *viz.*, −7·8. Nor were instances of great depression restricted to the month of January. At Káshghár, indeed, in the three months October to December, the radiation thermometer never fell more than 8·2° below that which marked the maximum temperature of the air in the shade. But at Yárkand, in every month subsequent to January, greater differences than this occurred on at least one or two days; and except in March—(when the difference was least and never exceeded 9·6°—) the registers shew many readings in which the depression of the radiation thermometer amounted to from 10° to 14°.

Temperature of air.—In respect of the temperature of Káshghária, Dr. Bellew remarks—

"Not less notable than this action of the sun's rays (previously quoted) is the wide range of the atmospheric temperature in the circle of the seasons. July is said to be the hottest month of the year by the natives. I have no data whereby to judge of its temperature. From the observations recorded

by Dr. George Henderson, during his visit to Yárkand with Mr. Forsyth in 1870, the temperature of the air on the plain country towards the close of August may be taken at 79° F. In May, according to my own observations, the maximum temperature in the shade was recorded at 97° F. on the 19th of the month at Yákshamba bazar, two marches to the south of Yárkand city. The minimum temperature of the air was recorded at 20° F., below zero, on the 19th February, at Tigarmiti near the Súghún Valley, at the foot of the mountains north of Artosh.

"These may be taken as the extremes of heat and cold in the course of the year, but are no criterion for the diurnal alterations, which, as a rule, are very equable; whilst, at the same time, the transition from one season to the next is a gradual process, singularly free from the sudden and great variations of temperature that characterize the climate of some parts of the Punjáb."

The official report from which these quotations are extracted gives three detailed registers of temperature for the months November 1873 to March 1874, *viz.*, one recorded at Yárkand by the Great Trigonometrical Survey Pundits, one at Káshghár (beginning in December) by Captain H. Trotter, and one partly at Yárkand and Yángi Hissár, but chiefly at Káshghár by Dr. Bellew. Unfortunately, Dr. Bellew's instruments were so exposed* as to suffer an undue loss of heat by radiation, so that the temperatures shewn by them are several degrees lower than those of the other two series. Having corrected the means of the Pundits' and Captain Trotter's series by range factors, computed from Dr. Scully's hourly and six-hourly observations, I have obtained values which I have little doubt are very near the true mean temperatures of the months of observation; and thus we have data for comparing the temperatures of five months in two successive years, and also those of the two cities of Káshghár and Yárkand for four months of the same year.

Table of mean monthly temperatures at Káshghár and Yárkand.

	1873.		1874.		1875.	Remarks.
	Kash.	Yar.	Kash.	Yar.	Yar.	
January	...	...	23·5(0)	20·0	20·9(1)	(0) Mean of 24 days only. (1) Mean of 25 days from 7th.
February	...	...	32·6	30·9	30·9	
March	...	...	38·6(2)	38·1(3)	50·7	(2) To 16th only. (3) To 25th only.
April	...	...	...	...	64·1	
May	...	...	...	...	69·4	
June	...	...	...	...	75·8	
July	...	...	...	...	81·7(4)	(4) To the 28th only.
October	...	...	44·1(5)	...	...	(5) Mean of 13 days from 19th.
November	...	38·9(6)	32·7	...	...	(6) Mean of 19 days from 12th.
December	26·8(7)	24·2	26·8(8)	...		(7) From the 12th only. (8) To the 28th only.

* On a board suspended on a tripod stand, easel-fashion, and without any shelter. The arrangement is represented as an accessory in one of the photographs (No. 50) which illustrate the report. It was placed on the north side of the house which shaded it from the sun.

It would appear from the above that the temperature of the winter months is remarkably uniform in consecutive years; but this may be, of course, fallacious, since the March temperature of Yárkand was very different in 1874 and 1875. Also, it would appear that, at the same season, Káshghár is warmer than Yárkand, notwithstanding its more northerly latitude. Interpolating probable values for the two deficient months of the table, and taking the mean of the whole, it results that the mean annual temperature of Yárkand is between 52° and 53°; which, adding 12° for its elevation, is equivalent to 64° or 65° at sea-level.

The absolute range of temperature shewn by Dr. Scully's registers, (*i. e.*, in the year 1875,) was 101°. The greatest cold registered by the shaded minimum thermometer at Yárkand, four feet above the ground, (on the 20th January,) was 2°. The greatest heat registered by the shaded maximum thermometer, (on the 11th July,) was 102·9°. Dr. Bellew quotes lower temperatures than the above, *viz.*, −3° in December 1873, −4° in January, and −5° in February 1874; but I have already pointed out that his temperatures were much affected by radiation, and were not those of the atmosphere. He observes that the temperature, on the open plain outside was considerably less than those quoted by him, and refers to an observation of Captain Trotter's at Tigarmiti,* north of Artosh, in the night of the 19th and 20th February 1874, in which the minimum thermometer recorded as low as 20°. This depression, however, appears to have been partly due to radiation. The lowest minimum temperature recorded at Káshghár, with a shaded thermometer, by Captain Trotter, in January 1874, was 5°. This occurred on the 13th, and again on the 16th of that month. The range of air temperature recorded by Dr. Scully exceeds any shewn by the Indian registers hitherto on record. It is approached most nearly at such stations as Sialkot, Rawalpindi and Mooltán; but it is to be observed that the extreme temperatures given in the Punjab reports hitherto published are certainly exaggerated by the effects both of solar and terrestrial radiation, the instruments having been exposed on open stands which afforded them insufficient protection.

On the coldest day, or that of the lowest average temperature, (the 18th January,) the mean of the thermometer readings was 17°; on the hottest, (the 11th July,) the mean was 88·9°, showing an annual range of 72°: and the mean temperature of the month of January was 20·9°, that of July 81·7°, showing an annual range of 60·8° on the means of the months. The following table of the mean temperatures of the hottest and coldest months at several places in India and other parts of Asia will show how greatly the annual range at Yárkand exceeds that of places to the south and west, while it is exceeded by that of places to the north and east. Also how, on proceeding from the more tropical part of Asia northward, the period of maximum annual temperature is gradually retarded; this last depends partly on the distribution of the summer rains.

* Túgharmati, north of Artysh, of Captain Trotter's Report.

Table showing the variation of the annual range of mean monthly temperature in different parts of Asia.

Place.	Years.	Coldest		Warmest		Annual range of monthly means.
		Month.	Temp.	Month.	Temp.	
Galle ...	6	January...	78·2	April ...	82·1	3·9
Bombay ...	18	„ ...	73·7	May ...	85·5	11·8
Calcutta ...	7	„ ...	68·5	„ ..	85·9	17·4
Nágpur ...	6	December	67·8	„ ...	93·3	25·5
Benares ...	7	January...	63·0	„ ...	92·6	29·6
Roorkee ...	7	„ ...	56·5	June ...	90·0	33·5
Lahore ...	7-8	„ ...	53·9	„ ...	94·4	40·5
Rawalpindi ...	8	„ ...	50·7	„ ...	93·3	42·6
Leh ...	2	„ ...	20·8	July ...	62·7	41·9
Tiflis ...	10	„ ...	32·2	August ...	75·8	43·6
Yárkand ...	2-1	„ ...	20·9	July ...	81·7	60·8
Barnaul ...	16	„ ...	—4·7	„ ...	67·1	71·8
Nertschinsk ...	14	„ ...	—21·3	„ ...	64·0	85·3

This subject of the annual range of temperature, and the geographical distribution of its variations, has already been treated of very comprehensively by Mr. Keith Johnson, junior, in a paper published in the 6th volume of the Proceedings of the Royal Society of Edinburgh. If, however, the range of Yárkand in 1875 did not greatly exceed the average, (which there seems no reason to assume,) that part of Mr. Keith Johnson's chart which refers to Central Asia will require to be modified, and the line of 60° annual range must be brought down several degrees to the southward, to about the margin of the Kuen Lun.

The passage has been quoted, in which Dr. Bellew remarks that the change from one season to another in Káshghária takes place very gradually, and "without any of those sudden and great variations of temperature that characterized the climate of some parts of the Punjab." That great and sudden changes of temperature are infrequent, appears also from the registers; and in November, with the exception presently to be noticed, and December, the mean temperature was remarkably uniform from day to day. But this is also the case in India, and indeed in all countries that are not subject to the rapid alternation of polar and equatorial wind currents; and against such vicissitudes Káshghária is well protected, in virtue of its geographical position.

The diurnal range of air temperature generally bears a direct relation to the amplitude of the annual range, since both depend in a great measure on the diathermancy of the atmosphere; the rapidity with which heat is absorbed and lost. At Yárkand, however, whether owing to the prevalent dust haze, or other cause, the mean diurnal

range of temperature, though high and uniform at different seasons, is not greater than at many places in Upper India, and is even surpassed at certain of them. On the average of the whole period of observation comprised in Dr. Scully's registers, it amounted to 26·6°. The least average range was in January, when it was 22° only; the greatest in June, when it was 30·2°. The greatest range on any one day was 47°, *viz.*, at Káshghár on the 21st October 1874. It was only 0·6 less on the 18th May 1875; and days occurred in most months, on which the range amounted to 40° and upwards. These ranges are surpassed at certain of the Punjab stations,* and even at Benares.

Barometric pressure.—Reference has already been made to the mean pressure of the atmosphere at Yárkand as a datum for determining its elevation; which determination assumes that, on the mean of the whole period of observation, the pressure is the same as at the reference station, Leh, when the latter is reduced to the horizontal plane passing through Yárkand. Whether this be so or not, and to what extent the assumption is erroneous, cannot, of course, be ascertained at present. The volumes of the Annales de l'Observatoire Physique Central for 1874 and 1875 have not yet reached me; but when received, they will afford in the registers of Taschkend, and perhaps of other places, data which will be valuable for verifying and correcting the present result. Till this shall be feasible, all that can be done in the way of comparison of this meteorological element at Yárkand, with its value at other places, will be to show the relative magnitude of its oscillations, and the seasons, &c., at which these occur; it is not possible, at present, to ascertain with any accuracy the distribution of pressures in this part of Central Asia, in the last two years, as referred to sea-level.

Some general conclusions on this head may, however, be drawn from the barometric charts of Messrs. Buchan† and Rikatcheff,‡ which shew that Yárkand probably has a mean sea-level pressure of about 30·2 in January, and 29·45 in July. But M. Rikatcheff's charts also point to, and Dr. Scully's and Captain Trotter's registers confirm the inference, that the highest pressure occurs not in January, as is generally the case on the plains of Upper India, but in November—apparently in the latter part of the month—as is also the case at Leh and such hill stations as Simla and Darjeeling on the Himalaya, at elevations of about 7,000 feet; but whereas these stations show a secondary maximum in the spring months, nothing of the kind is perceptible at Yárkand.

In the following Table I give the mean pressure at Yárkand for several months of 1873—75, from Captain Trotter's and Dr. Scully's observations. The former, recorded at the hours 9, 12, 15, 18 and 21h, have been reduced to a true mean by factors deduced from Dr. Scully's hourly and six-hourly observations. The means for October, Novem-

* I do not make this statement on the authority of the published reports, since, up to the middle of 1875, the apparent range of temperature at the Punjab stations was much affected by too free exposure of the instruments.

† Transactions, Royal Society of Edinburgh, Vol. XXV, p. 575.

‡ La distribution de la Pression Atmosphérique dans la Russie d'Europe. Repert. für Met., volume IV, No. 6.

ber and December 1874 are reduced from the registers kept at Káshghár, by applying a correction for the difference of elevation. Both Captain Trotter's and Dr. Scully's registers show that the changes of pressure are so uniform at the two places, that this proceeding is allowable.

Table of mean monthly pressures at Yárkand.

Months.		1873.	1874.	1875.	Remarks.
January ...	..	...	26·077	(1) 26·120	(1) 25 days from 6th.
February ...	...	...	25·957	25·992	
March ...	...	...	(2) ·841	·912	(2) 25 days to 25th.
April ...	...	...	...	·891	
May ...	...	...	...	·844	
June ...	...	...	...	·738	
July ...	...	...	...	(3) ·645	(3) 28 days to 28th.
October ...	...	...	(4) 26·138	...	(4) 13 days from 19th.
November...	...	(5) 26·130	·229	...	(5) 19 days from 12th.
December ...	...	·056	(6) ·126	...	(6) 28 days to 28th.

From this it would appear that, throughout the winter of 1874-75, the pressure was much higher than in that of 1873-74; a difference which I cannot trace either to the instruments used, or to any difference in their elevation. If we may assume that the pressure at Yárkand on the 25th November was proportionately as high as at Káshghár, the range of pressure at Yárkand during the eight months of observation, (which included the months of highest and lowest pressure in the year,) amounted to 1·372 inch. On the day above mentioned, a pressure of 26·573 was recorded at Káshghár at 10 A.M., which, at the temperature then prevailing, is equivalent to 26·710 at the elevation of Yárkand. On the 12th July, at Yárkand, at 4 P.M., the barometer registered 25·338, and the mean pressures of these two days, (reduced as before,) were 26·694 and 25·405. On the means of the months, the range in 1874-75 (when reduced to the level of Yárkand,) was 0·584, which, indeed, greatly exceeds the range at Leh and the Himálayan hill stations; and to some extent even that at Dehra, Roorkee, and some places on the plains of Upper India near the foot of the Himálaya, but is exceeded by that of the Punjab stations and those situated along the line of the Ganges. It is, however, in all probability in excess of any oscillation of pressure, at an equal elevation above sea-level, in any part of India.

The irregular or non-periodic oscillations of pressure are for the most part of moderate amplitude, as compared with those that occur at European stations under the same latitude; and are not very greatly in excess of those shewn by the Punjab registers; but

they present one or two remarkable features deserving of further study. The amplitudes of the variations of pressure in each month are shewn by the following Table:—

Table showing the amplitude of the barometric non-periodic oscillation in each month at Yárkand and Káshghár.

Months.	1873.					1874.					1875.				
	Highest.	Day.	Lowest.	Day.	Range.	Highest.	Day.	Lowest.	Day.	Range.	Highest	Day.	Lowest.	Day.	Range.
January	...	...	...	...	...	26·327	17th	25·862	21st	·465	26·412	27th	25·724	7th	0·688
February	...	...	...	...	...	·172	19th	·677	8th	·495	·296	28th	·701	17th	·595
March ...	...	...	...	...	...	·217	16th	·512	2nd	·705	·376	1st	·668	12th	·708
April ...	...	...	...	...	...	...	...	...	...	...	·139	28th	·625	1st	·514
May ...	...	...	...	...	...	...	...	...	...	...	·189	11th	·590	30th	·599
June ...	...	...	...	...	...	...	...	...	...	...	·026	2nd	·512	23rd	·514
July ...	...	...	...	...	...	...	...	...	...	...	25·816	8th	·338	12th	·508
November	26·452	28th	25·882	25th	·570	26·573	25th	25·613	21st	0·930	...	...	...	...	...
December	·322	8th	·702	23rd	·620	·300	24th	·779	12th	0·521	...	...	...	...	...

The greatest irregular or non-periodic oscillation of pressure, registered during these portions of two years, was that between the 21st and 25th November 1874, when the rise amounted to nearly an inch. The subsequent fall was less, amounting to only ·556 up to the 29th; after which minor oscillations followed. It may be only a fortuitous coincidence, but it is certainly noteworthy, that an oscillation similar in character, though of less amplitude, took place in the previous year, only four days later in the same month, *viz.*, from the 25th to the 28th, the pressure then declining to the 30th. On referring to the registers of November 1873 and 1874 for the west of Europe, I find that the crest of what was formerly spoken of as the great November wave, passed the British Isles on the 16th and 17th November in 1873, and on the 8th in 1874, thus leaving an interval of only 11 days in the former, but of 17 in the latter year between the dates of maximum pressure in England and at Yárkand. This coincidence, notwithstanding the difference of the interval, is at least striking, and suggests that there may be some kind of connection between the two phenomena: and that there is a certain connection is not improbable. But the admirable charts of Captain Hoffmeyer for 1874 clearly negative the idea which at first suggested itself, *viz.*, that a wave of air passed from West to East across Europe and Central Asia. They show that, from the 1st to the 10th of the month, an east and west axis of high pressure lay across Southern Russia and Central Europe, and even further westward, across a great part of the Atlantic, while the north Atlantic was an area of low pressure; that from the 10th this depression extended southwards, invading Europe, and dividing the original axis of high pressure into two independent maxima, one of which extended over the East Atlantic, the other receding towards Siberia. In this latter region, the pressure rose remarkably from the 18th to the 21st, while the trough of low pressure which occupied Central and Southern Europe extended eastwards beyond the Caspian, (at the limit of the chart,) bounded on the south by another area of high pressure in Armenia and Persia. Lastly, from the 21st to the

25th, a wave of high pressure advanced from Siberia over Europe, and this advance was coincident with the remarkable rise in Yárkand.

Although, then, Captain Hoffmeyer's charts do not extend sufficiently far eastward to allow of an absolute identification of the barometric oscillations of Yárkand with those of Eastern Europe and Western Asia, the facts above stated seem to indicate that, the meteorological vicissitudes of Central Asia, south of the Thian Shan, are probably much affected by those of the regions beyond that range and the Pamir. The Kuen Lun and Kárákorám present, however, a more impassible barrier. Leh is but 4° of latitude to the south of Yárkand. But the barometric oscillation of nearly an inch in November 1874 at the latter place is not distinctly identifiable in the Leh register, and, if represented at all, is so only by a rise of a little more than 0·1 between the 24th and 25th, and a continuance of the high pressure for the two days succeeding; and the smaller oscillation of more than half an inch, between the 25th and 28th November of the previous year, is absolutely untraceable in the Leh curve of pressure.*

This comparative independence of the barometric oscillations north and south of the Kuen Lun is well illustrated by Captain Trotter's projection of the barometric curves for Káshghár, Yárkand, Leh and Dehra, during the four months December 1873 to March 1874.† But this independence is by no means absolute. Many oscillations at Yárkand, of much smaller amplitude than those referred to above, are reproduced in the Leh curves; and generally (it is to be observed) one or two days later than at Yárkand. Perhaps these apparently conflicting facts may be reconciled by the inference that the cases of great exaltation of pressure, of which the November waves above cited are examples, are strictly phenomena of the lower atmosphere, and are therefore unfelt at elevations of 16,000 to 17,000 feet above the land surface of Káshghária, which elevation may be taken as the average of the Mústágh range above Yárkand.

In both years, the November rise of pressure was accompanied by a considerable fall of temperature. In 1873, the mean day temperature (the mean of five observations at three hourly intervals, from 9 A. M. to 9 P. M.) of the 25th was 43·1; that of the 29th was 29·2. Up to the former date, the temperature had been very uniform from the beginning of the register on the 12th of the month; and for a fortnight at least after the latter date, a similar uniformity of low temperature prevailed, never exceeding an average of 33·4, nor falling below one of 28°. This is shewn in the following table of day temperatures :—

Before the fall.				After the fall.			
Date.	Temperature.	Date.	Temperature.	Date.	Temperature.	Date.	Temperature
12th	43 9	20th	43·5	29th	29·2	7th	31·2
13th	44·2	21st	43·5	30th	30·4	8th	33·4
14th	41·2	22nd	46·2	Dec. 1st	29 6	9th	31·7
15th	43 7	23rd	48·4	" 2nd	30·8	10th	28·1
16th	44·0	24th	46·9	" 3rd	31 4	11th	30 6
17th	40 7	25th	43 1	" 4th	30·2	12th	32·2
18th	43·2	...	...	" 5th	29·6	13th	29·5
19th	43 4	...	...	" 6th	29·5	14th	28·0

* Punjab Meteorological Report for 1873.

† Yárkand Report, page 292, plate II.

The much greater rise of pressure in November 1874 was accompanied by temperature phenomena of precisely the same character. For twelve days, up to the 21st, the temperature had been remarkably uniform, the mean never falling below 33° nor rising to 36°. On the 21st it suddenly rose to 44·5° and then fell to 29·7° on the following day, and gradually to 18·6° on the 26th. After the 27th it rose gradually, but did not attain to its former height.

In 1874 the rise of pressure was preceded, three or four days, by a change of wind from west to north-east and east, and the wind remained in the latter quarter during the cold days that followed. In 1873, however, no striking change of wind direction is shewn in the registers. Other accompaniments of the change in 1874 were, a thick haze (possibly a dust haze) obscuring the sky, and a fall in the absolute but a rise in the relative humidity of the air, which lasted till the middle of the following month. There was also a marked fall in the differential temperature of the solar radiation, which was probably due to the thick haze. The temperature of ground radiation also fell, but not in an appreciably greater measure than that of the air.

The registers disclose some other cases of marked oscillations of pressure, generally accompanied by a change of temperature, which extends over several days. One of these took place almost immediately after the arrival of the Mission at Káshghár, when the barometer fell through about 0·3 inch in two days, and during the six days following rose through 0·7 inch. The rise was accompanied by a fall of temperature of about 6° on the mean of the day. Again, at the end of February, a rise of 0·6 inch took place in two days, followed by a fall of somewhat greater amount on the first four days of March. This was accompanied by a fall of 3° of temperature, followed by a rise of 7·5° on the mean of the day.

ANEMOMETRY.—Dr. Bellew sums up the anemometric features of Káshghár, at different seasons, in the following extracts, and gives the number of windy days in each month. These I reproduce below in a tabular form.

"The winter or *cish* extends over December, January and February. It is a still cold season, with a more or less constantly overcast sky, and an atmosphere rarely disturbed by winds." "The spring or *arla-yáz* gradually emerges from winter, and towards its close suddenly lapses into summer. It extends over March, April and May * * * * *. Vegetation shows no signs of activity till the middle of this month, when the willow, by several days' precedence, begins to unfold its leaf buds and wave in the breezes, which now dispel the clouds of winter, and make way for the haze, which, gradually during the next month, takes possession of the air, and by the end of the season completely obscures the hills and distant prospect around." "The summer or *yáz* extends over the months of June, July and August * * *. Whirlwinds and circular currents now and again career across the plain in fitful eddies, but there are no rain-storms, though dust and sand-storms with thunder and electrical disturbance do occasionally occur. They clear the atmosphere, and are succeeded by a brief lull, and occasionally by a slight rain shower, before the sun resumes its power, much as in Northern India. "The autumn, or *kúz*, like the winter, is a more or less still season, ushered in with north-western breezes, which disperse the summer haze, and correct the aridity of the air by the diffusion of cloud moisture, till gradually the sky becomes overcast as winter * * *."

The table of windy days during the seven months of Dr. Bellew's residence in the country is as follows:—

Months.	Days of wind.	Total.
November	3 N. W.	3
December	2 W., 2 E.	4
January	1 N., 1 E.	2
February	2 N. E., 2 N.	4
March	20 N. W., 6 S. E.	26
April	22 N. W., 2 S. W.	24
May	16 N. W., 6 S. E.	22

Dr. Bellew was unprovided with an anemometer, and he does not define what he reckons as a day of wind. Dr. Scully's registers show much less difference at the different seasons than would be inferred from the above table.

On the subject of the winds, Dr. Henderson remarks.*—"The winds in Thibet and Yárkand (referring apparently to the mountain region,) always blow up the valleys during the day, and down the valleys during the night," and with reference to the course of the higher currents—"When clouds were seen, they were always moving in a direction from south-west to north-east nearly."

The chief characteristics of the winds as regards velocity and direction shewn by Dr. Scully's registers, are exhibited in a condensed form in the two following tables, one of which gives the percentage of the observed winds under each of the eight principal points, and the other the number of days on which the movement was under 20, 50, and 100 miles, &c., respectively.

Table showing the percentage of winds from each compass point in each month at Káshghár and Yárkand.

Months.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.
October	4	4	31	...	...	4	38	19
November	6	21	21	2	...	...	37	13
December	41	21	13	1	...	1	8	15
January	11	20	19	12	2	5	15	16
February	8	11	13	18	4	2	27	17
March	12	10	3	21	6	6	19	23
April	11	7	6	13	8	5	15	35
May	6	...	4	17	6	1	19	47
June	11	5	...	14	11	1	22	36
July	26	4	2	7	5	...	10	46
Mean ...	14	10	11	11	4	2	21	27

* From Lahore to Káshghar, page 357.

Table showing the total diurnal movement of the wind at Yárkand.

Months.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
January	...	7	12	—	—	—	...	19
February	...	6	18	4	...	—	—	28
March	...	1	11	18	1	—	...	31
April	—	1	16	9	4	—	—	30
May	...	4	9	8	7	1	2	31
June	—	1	14	7	7	—	1	30
July	—	4	13	6	3	—	..	28
TOTAL	—	21	93	54	22	1	3	197

The prevalent wind directions are there from between north and west; except in the winter months, when, and especially in December, east and north-east winds predominate. Messrs. Buchan's* and Wojeikoff's† charts show that these directions are such as might have been anticipated from the conditions of pressure in Central Asia. The area of lowest pressure, in July, in Central Asia, is shewn to extend to the north-east of Yárkand in Buchan's, to the east in Wojeikoff's chart; while, in both charts for December, Yárkand is shown to occupy a positiono n the base of a vast triangular area of high pressure, the centre of which is in the neighbourhood of Lake Baikal. Hence, the winds, apart from merely local influences, would tend to be north-westerly in July, and indeed more or less through the summer; and from east or north-east in the winter months.

In a country so shut in by mountains, and where the winds are so light, and influenced by local conditions, it may be doubted whether the thermal and hygrometric characteristics of the winds throw much light on the general movements of the atmosphere. I have, however, investigated these characteristics in the case of the winds of Yárkand by treating the data for the seven months, January to July, in the following manner. The temperature, corresponding to each observation of a particular wind-direction, was taken as a difference above or below the mean temperature of the hour of observation for that month; and these differences for the same months being tabulated under the 16 compass points recorded, the sums of the differences were afterwards reduced to 8 compass points, and then divided by the number of observations.

* Trans. Roy. Soc. Edin., vol. XXV, pl. 25 and 26.

† Petermann's Mittheilungen. Ergänzungsband VIII, No. 38, Pl. 1, 2.

The vapour tensions were treated in the same way and the results are given in the following Table :—

Table shewing the differential temperature and vapour tension of the wind from each quarter at Yárkand.

Wind.	Temperature differences.					Vapour-tension differences.				
	Sums. °	Observations.	Sums. °	Observations.	Means. °	Sums inch.	Observations.	Sums inch.	Observations.	Means inch.
N.	—25·4	20	—17·5	49·5	—0·35	—·161	20	—·573	49·5	—·011
N. N. E.	—19·6	16				—·556	16			
N. E.	+23·2	15	+29·4	31	+0·95	—·079	14	—·391	30	—·013
E. N. E.	+32·0	16				—·069	16			
E.	+15·5	8	+72·1	26	+2·77	—·157	8	—·212	26	—·008
E. S. E.	+81·2	20				—·041	20			
S. E.	+35·7	41	+72·8	60	+1·21	+·395	41	+·651	60	+·011
S. S. E.	—7·0	18				+·552	18			
S.	—18·2	13	—11·5	25	—0·46	—·087	13	+·092	25	+·004
S. S. W.	+20·5	6				—·194	6			
S. W.	—31·9	6	—11·6	11·5	—1·00	+·035	6	+·001	11·5	0
W. S. W.	+20·3	5				+·126	5			
W.	—42·2	49	—89·3	77·5	—1·14	+·260	49	+·078	77·5	+·001
W. N. W.	—74·1	52				—·491	52			
N. W.	—28·3	82	—47·6	129·5	—0·37	+·421	82	+·012	129·5	0
N. N. W.	+35·4	43				—·268	43			

There can be little doubt that the small variations of temperature and vapour-tension shewn by this table are due to purely local conditions. The highest temperature characterizes the east wind, which comes direct from the Gobi desert; indeed, the form of the thermal wind-rose almost exactly expresses the extent of the plain in different directions around Yárkand. The differences of vapour-tension with different winds are very small; and, as it seems to me, have reference to the direction of the irrigated and cultivated tract extending along the foot of the mountains. These explanations are quite in accordance with the fact that, the rate at which the air travels in this secluded plain is so low, that any characteristics of a foreign origin that it may once have possessed must soon give way to purely local influences.

The vapour-tension observation of 16 h. on the 27th March is omitted, as it deviated too much from the others to be admitted with so small a number of observations, and the wind being so light at the time.

The diurnal variation of the wind, which is very decidedly indicated in some of the registers for certain months, will be treated of in connection with the subject of the hourly observations.

Hygrometry, Clouds and Rainfall.—This subject necessarily furnishes but a subordinate chapter in the meteorology of a country such as Káshghár. Nevertheless, it is not without some features of peculiar interest. The absolute humidity of the air varies, as might have been anticipated, directly with the temperature, being lowest in January, highest in July; and the range, on the means of the months, is 0·117 inch. The lowest tensions computed from direct observations of the psychrometer were ·039, (on the 2nd and 5th February,) and ·040 (on the 29th, 30th and 31st January). The still lower tensions ·031 and ·032 inch were computed from the temperatures of the self-registering minimum thermometers, corresponding to 0·37 grs. of water-vapour to the cubic foot of air. The highest vapour-tension observed was 0·763, on the afternoon of the 19th July; which, at the temperature then prevailing, indicates the presence of 8·01 grs. of vapour in the cubic foot of air.

The relative humidity of the atmosphere was highest in December (at Káshghár), when it amounted, on an average, to 84 per cent. of saturation. It diminished rapidly till April and May, in which months it averaged only 29 and 31 per cent., and the readings of the dry and wet bulb thermometers on several days indicated only 9 per cent. of saturation. In June it increased to 34 per cent.; and in July, notwithstanding the high prevailing temperatures, it rose to 47 per cent. on the average of the month, and on two days to 91 per cent. of saturation.

This rise in the relative humidity of the atmosphere of Káshghár in the months of June and July is a very striking fact; and at a first glance seems to suggest an influx of the Indian monsoon across the southern mountain barrier of the country. But on consideration, it appears to me that the difficulties which oppose themselves to this view are not to be overcome; and that, more probably, the accession of vapour indicated by the registers is mainly of local origin.

It is true that, as far as observations have been made on the upper wind currents, above the Himálaya, they are from the south-west; not only in the summer monsoon, but at all seasons of the year. But were such a current to descend from the heights of the Mústágh on the plains of Yárkand, instead of being a comparatively damp wind, it would, in all probability, have the parching characters of the Alpine Föhn. Moreover, the prevailing direction of the wind in July is inconsistent with this supposition. The table on page 56 shews that, in that month, the winds are characteristically north-west, a direction quite irreconcilable with that of a current descending from the Himálaya. But, north-west from Yárkand lies the cultivated tract of country which is under constant irrigation from April to October; and which, at that season, must furnish a large

amount of evaporation. In support of the view that this is the source of the vapour, I give the following data for the hygrometric wind-rose of June and July:—

Table shewing the differential vapour-tension and relative humidity of the wind from each quarter at Yárkand in June and July.

Wind direction.	Vapour-tension.			Relative humidity.		
	Sums.	Observations.	Means.	Sums.	Observations.	Means.
N.	—·157	8	—·020	—21	8	— 2·6
N. N. E.	—·385	6	—·064	—72	6	—12·0
N. E.	—·042	2	—·021	—18	2	— 9·0
E. N. E.	...	0	...	...	0	...
E.	—·073	1	—·073	+2	1	+2·0
E. S. E.	...	0	...	...	0	...
S. E.	+·080	7	+·011	+12	7	+1·7
S. S. E.	+·274	11	+·025	+20	11	+1·8
S.	—·097	4	—·024	0	4	0
S. S. W.	...	0	...	...	0	...
S. W.	...	0	...	...	0	...
W. S. W.	—·054	1	—·054	— 7	1	—7·0
W.	+·362	9	+·040	+33	9	+3·6
W. N. W.	—·031	18	—·002	—14	18	—0·8
N. W.	+·524	28	+·019	+85	28	+3·0
N. N. W.	—·377	21	—·018	—88	21	—4·2

The table represents only the average excess or defect of each wind observation, in comparison with the mean of the corresponding hour and month; and, taken by itself, is therefore not calculated to illustrate the conditions which determine the preponderant humidity of June and July over other months. But it does shew one fact, which is not without importance, *viz.*, the great variation of humidity and vapour-tension consequent on small variations in the direction of the wind.

The great majority of the winds are from either west-north-west, north-west or north-north-west. These, therefore, afford the best averages for comparison. Now north-west winds are on the average 3 per cent. in excess of the mean relative humidity west-north-west 0·8, and north-north-west 4·2 per cent. below it. West winds, again, are 3·6 per cent. above the average; facts which indicate that the source of the vapour is very local. South-south-east and south-east winds, which are next in frequency to north-west, like the latter, sweep over the irrigated tract, and also, like them, have a humidity above

the average; while winds from between north and south-east, which come direct from the desert, are extremely rare in June and July. It seems, then, more probable that the increased humidity of June and July is owing to the increased local evaporation, and the prevalence of winds from those quarters where the chief evaporating surface lies, than that it affords any evidence of the influence of the Indian monsoon.

The registers seem to shew that clouds are more prevalent than might have been anticipated in so dry a country; but this is, probably, in a measure, to be explained by the practice of entering, as a completely overcast sky, (cloud =10) all cases in which the sky was obscured by the dust haze. Such, at least, I judge to be the case from the registers, wherein 10 is entered in the cloud column repeatedly, without the initial *o* (overcast), but with *m* or *m m* (hazy) in the columns for the Beaufort's initials. If all such cases be struck out, the mean cloudiness of the sky will be very much reduced in appearance, especially in the month of April; and February and March will be those which display the greatest prevalence of cloud. In both these months the sky was frequently entered as overcast.

Falls of snow are not recorded in Dr. Scully's register. Rain of measurable quantity was recorded on two days in March, one day in May, one in June and four in July; the total quantity amounting to 0·52 inch.

CONCLUSION.—The general conclusion to be drawn from the above discussion is that, in a meteorological point of view, Káshghária is in a great measure independent of the influence of the surrounding continent; but that it is more nearly related to the system of Northern Asia than to that of the Indian monsoon region. With the latter, indeed, its connection is of the very slighest character; and may be said to be restricted to a certain probable interchange of air currents in the upper half of the atmosphere. Such a result might have been anticipated from a consideration of its geographical features; and it confirms the conclusion independently arrived at from a study of the meteorological phenomena of India.*

In the valuable barometric charts originally drawn up by Mr. Alexander Buchan, as well as in the later chart for July, published by Mr. Wojeikoff, the isobars are so drawn as to represent a continuous barometric depression in the summer months, extending between North-Western India and Central Asia. The registers that have lately been furnished from Leh, as well as those of the stations on the southern margin of the Himalaya, show, however, that such a representation is really misleading. At heights of 7,000 feet on the Himalaya, the average difference of pressure between January and June or July is not more than 0·12 to 0·16 inch; and the average of two years' registers at Leh would seem to shew that, at that station, 11,500 feet above the sea, the annual oscillation is such, that the mean pressure of the month of June is actually higher than that of January. The following table shews the mean pressure of each month at the stations

* Winds of Northern India. Phil. Trans: Vol. 164, pp. 581, 617.

Darjeeling, Simla and Leh, elevated respectively 6,912 feet, 7,071 feet, and 11,538 feet above sea level:—

*Table shewing the annual variation of pressure over the Himálaya and Tibet.**

	Darjeeling.		Simla.		Leh.	
	Mean.	Difference.	Mean.	Difference.	Mean.	Difference.
January	23·387	+·024	23·225	+·010	19·598	—·060
February	·365	+·002	·193	+·008	·568	—·090
March	·360	—·003	·197	+·012	·606	—·052
April	·366	+·003	·207	+·022	·702	+·044
May	·331	—·032	·142	—·043	·674	+·016
June	·274	—·089	·061	—·124	·631	—·027
July	·268	—·095	·069	—·116	·609	—·049
August	·308	—·055	·101	—·084	·627	—·031
September	·364	+·001	·194	+·009	·686	+·028
October	·427	+·064	·227	+·042	·715	+·057
November	·470	+·107	·293	+·108	·767	+·109
December	·441	+·078	·254	+·069	·711	+·053
Year ...	23·363	...	23·185	...	19·658	...

These facts suffice to shew that the annual oscillation of pressure over the Himálaya and the Thibetan plateau is of a character quite different from that of India on the one hand, and of Central Asia on the other. The high pressure of the winter and the low pressure of the summer months, in both these regions, are phenomena restricted to the lower atmosphere; arising in the one case from its cooling and condensation, in the other from its expansion and consequent diminished density; and since all communication in the lower half of the atmosphere is absolutely barred by the Himálayo-Tibetan barrier, the two areas of high winter and low summer pressure are independent and distinct. The wind systems dependent on them are also distinct; the Indian monsoon being drawn from the equatorial seas, the currents of Central Asia mainly from Europe and the Arctic Ocean.

HORARY READINGS.

The observations recorded hourly on four days in each month at Yárkand and Káshghár, together with the regular observations at intervals of six hours on all other days, have afforded very ample and valuable materials for a knowledge of the diurnal

* The Darjeeling means are obtained from six to eight years' registers, those of Simla from three and those of Leh from the registers of two years and four months, the first eight months of the year being the means of two years, the last four of three years.

variation of some of the chief meteorological elements for the nine months, November to July, during which the mission remained in Káshghária. The original observations of the barometers and thermometers (reduced and corrected for the errors of the instruments) and the computed hygrometric data, together with the anemometer readings and observations, are given in full in the Appendix.

In deducing the mean curves of temperature, pressure, &c., I have grouped the observations under three periods :

November to February,
March to May,
June and July,

and have proceeded in the following manner :—

The means of the hourly readings at each hour were first taken, the series beginning and ending with the midnight observations. Next, the difference of the initial and final (midnight) means was equally distributed by interpolation throughout the series; the two midnight observations being thus reduced to the same value. Thirdly, the difference of each hourly value above or below the common mean having been substituted for the mean value corrected as above, the mean differences of the 4h. 10h. 16h. and 22h. readings, from the daily registers of the same months, were substituted for those of the hourly registers; and the intervening hours corrected by simple proportional interpolation. Thus, let k_4 k_{10} k_{16} k_{22} be the corrections for the four six hourly epochs, then—

$$k_5 = k_4 + \tfrac{1}{6}\ (k_{10} - k_4)$$
$$k_6 = k_4 + \tfrac{2}{6}\ (k_{10} - k_4)$$
$$k_7 = k_4 + \tfrac{3}{6}\ (k_{10} - k_4)\ \text{\&c.}$$

are the corrections for 5h. 6h. 7h. &c. Lastly, the whole series was corrected by Bessel's interpolation formula, computed to four periodical terms. The general form of this formula is as follows. Let x be the probable value of an element (temperature, pressure, &c.,) at any given hour. Then, representing that hour by degrees of arc, measured from midnight as 0, at the rate of 15° for each complete hour, let its numerical expression be n 15°.

$x = M + U' \, sin.(n\,15° + u') + U'' \, sin.(n\,30° + u'') + U''' \, sin.(n\,45° + u''') + U'''' \, sin.(n\,60° + u'''')$, wherein M is the mean of the day, U' U'' U''', &c., constants expressed in decimals of an inch for pressure, in degrees for temperature, and u', u'', u''', &c., constant values of arc.*

* Readers who may be unacquainted with this useful formula may be referred to Bessel's original paper in Schumacher's Ast Nachrichten, or the translation by Mr. R. H. Scott, published in the Appendix to the Quarterly Weather Report of the Meteorological Office, London, for 1870. Also, to Herschell's Meteorology, page 142, where the whole working is illustrated by an example.

Diurnal variation of temperature.—The co-efficients of Bessel's formula for the average temperature variation in each group of months above specified, and the mean of the whole, are as follow:—

	M.	U′	u′	U″	u″	U‴	u‴	U⁗	u⁗
November to February ...	27·82	9·36	224°50′	3·53	50°45′	0·56	246°40′	0·49	210°46′
March to May	61·40	11·32	232°26′	2·64	84°21′	0·91	36°45′	0·57	234°11′
June and July	78·75	12·22	237°6′	2·56	81°43′	0·62	82°10′	0·58	257°41′
Nine months	50·33	10·54	230°23′	2·84	67°23′	0·23	36°7′	0·45	226°42′

From these values the following mean hourly temperatures and hourly variations have been computed. The resulting curves are represented graphically on Plate VIII.

	November to February.		March to May.		June and July.		Nine Months.	
	Mean.	Difference.	Mean.	Difference.	Mean.	Difference.	Mean.	Difference.
Mid.	23·19	−4·63	55·15	−6·25	71·08	−7·67	44·64	−5·69
1	22·19	−5·63	53·74	−7·66	69·61	−9·14	43·35	−6·98
2	21·62	−6·20	52·39	−9·01	68·41	−10·34	42·28	−8·05
3	21·15	−6·67	51·03	−10·37	67·35	−11·40	41·29	−9·04
4	20·34	−7·48	49·82	−11·58	66·69	−12·06	40·38	−9·95
5	19·21	−8·61	49·42	−11·98	66·99	−11·76	39·90	−10·43
6	18·42	−9·40	50·68	−10·72	68·93	−9·82	40·47	−9·86
7	18·93	−8·89	54·00	−7·40	72·60	−6·15	42·66	−7·67
8	21·32	−6·50	58·86	−2·54	77·34	−1·41	46·36	−3·97
9	25·29	−2·53	63·96	+2·56	82·00	+3·25	50·78	+0·45
10	29·92	+2·10	68·06	+6·66	85·75	+7·00	54·98	+4·65
11	34·18	+6·36	70·62	+9·22	88·39	+9·64	58·29	+7·96
Noon.	37·41	+9·59	71·99	+10·59	90·36	+11·61	60·60	+10·27
13	39·43	+11·61	72·84	+11·44	91·87	+13·12	62·07	+11·74
14	40·14	+12·32	73·37	+11·97	92·63	+13·88	62·68	+12·35
15	39·45	+11·63	73·21	+11·81	92·01	+13·26	62·21	+11·88
16	37·42	+9·60	71·84	+10·44	89·69	+10·94	60·42	+10·09
17	34·41	+6·59	69·20	+7·80	86·13	+7·38	57·52	+7·19
18	31·26	+3·44	65·94	+4·54	82·39	+3·64	54·29	+3·96
19	28·77	+0·95	62·94	+1·54	79·36	+0·61	51·52	+1·19
20	27·24	−0·58	60·74	−0·66	77·34	−1·41	49·60	−0·73
21	26·39	−1·43	59 24	−2·16	75·88	−2·87	48·36	−1·97
22	25·56	−2·26	57·96	−3·44	74.43	−4·32	47·26	−3·07
23	24·44	−3·38	56·60	−4·80	72.77	−5·98	46·01	−4·32

This table shews that the normal daily range of temperature in the three groups of winter, spring and summer *months*, was 21·7°, 21° and 25·9° respectively, and 22·8° on the mean of the nine months. This is smaller than the mean range of temperature deduced from observations of the maximum and minimum, as might indeed be expected, since these latter shew the range between the extreme temperatures at whatever hour these extremes may occur, while the range shewn by the curves is that between the average temperatures of the average hours of maximum and minimum only.

The average times of lowest temperature as given by the four curves are—

November to February	6 hs.	6 min.
March to May	4 „	41 „
June and July	4 „	11 „
Nine months	4 „	57 „

and the average hours of highest temperature—

November to February	14 hs.	
March to May	14 „	16 min.
June and July	14 „	3 „
Nine months	14 „	4 „

and since the mean hours of sunrise in north latitude 38°25′ are—

November to February	7 hs.	3 min.
March to May	5 „	34 „
June and July	4 „	47 „

the lowest temperature precedes sunrise by nearly an hour, while the hottest falls from two to two and a quarter hours after noon, being latest in the spring.

Diurnal variation of pressure.—The co-efficients of the barometric formula for the three groups of months, and the mean of the nine months, are as follow. The mean of November and December have been reduced to the values for Yárkand :—

	M	U'	u'	U''	u''	U'''	u'''	U''''	u''''
November to February ...	26·117	·0179	355° 31′	·0201	157° 15′	·0010	351° 29′	·0020	180° 35′
March to May ...	25·896	·0378	0° 41′	·0251	169° 19′	·0016	269° 30′	·0018	211° 37′
June and July ...	25·691	·0178	8° 32′	·0205	161° 23′	·0025	129° 19′	·0020	85° 52′
Nine Months ...	25·919	·0318	4° 33′	·0215	161° 59′	·0013	10° 8′	·0007	169° 4′

from which the following values have been computed :—

	November to February.		March to May.		June and July.		Nine Months.	
	Mean.	Difference.	Mean.	Difference.	Mean.	Difference.	Mean.	Difference
Mid	26·123	+·0058	25·899	+·0025	25·709	+·0176	25·959	+·0099
1	·118	+·0014	·895	—·0010	·707	+·0164	·957	+·0078
2	·115	—·0022	·896	—·0005	·705	+·0138	·955	+·0059
3	·113	—·0038	·900	+·0045	·706	+·0146	·956	+·0065
4	·114	—·0032	·909	+·0127	·712	+·0214	·960	+·0105
5	·117	—·0002	·918	+·0222	·724	+·0328	·967	+·0178
6	·123	+·0058	·928	+·0321	·735	+·0443	·976	+·0270
7	·132	+·0152	·938	+·0417	·742	+·0515	·985	+·0361
8	·144	+·0265	·945	+·0491	·743	+·0520	·992	+·0426
9	·152	+·0352	·947	+·0509	·737	+·0461	·993	+·0439
10	·153	+·0362	·940	+·0440	·726	+·0349	·987	+·0377
11	·144	+·0269	·924	+·0276	·710	+·0192	·973	+·0237
Noon	·126	+·0094	·901	+·0047	·691	—·0005	·953	+·0039
13	·107	—·0103	·877	—·0192	·669	—·0223	·931	—·0176
14	·091	—·0257	·857	—·0391	·648	—·0427	·913	—·0361
15	·084	—·0333	·844	—·0518	·634	—·0574	·901	—·0479
16	·083	—·0335	·840	—·0564	·627	—·0638	·897	—·0518
17	·088	—·0289	·843	—·0533	·629	—·0618	·900	—·0485
18	·095	—·0220	·853	—·0435	·638	—·0534	·909	—·0398
19	·103	—·0138	·867	—·0288	·650	—·0412	·921	—·0280
20	·112	—·0051	·883	—·0126	·661	—·0267	·934	—·0151
21	·120	+·0028	·896	+·0005	·680	—·0112	·946	—·0034
22	·125	+·0079	·903	+·0071	·694	+·0031	·954	+·0053
23	·126	+·0087	·903	+·0067	·704	+·0133	·959	+·0096

The four curves are represented graphically on Plate VIII. They exhibit many striking and characteristic features. In the first place, the amplitude of the mid-day semi-oscillation exceeds that hitherto recorded at any other place under an equally high latitude.* Even in the winter it averages nearly 0·07 (·0697) between

* The nearest approach to this amplitude among the stations in equally high latitude, enumerated by Mr. A. Buchan in his recent paper on this subject, are afforded by Sacramento in latitude 38° 34,' and Fort Churchill in latitude 39° 18'. The following are the mean annual ranges and those of the months of greatest range, with the corresponding ranges at Yárkand ?

	Annual.	Maximum.
Fort Churchill	·072 ...	·091
Sacramento	·070 ...	·081
Yárkand (9 months)	·0957 ...	·1158

10 A. M. and 4 P. M.; and in June and July, ·0987 between those hours, and the total of ·1158 between the even hours nearest to maximum and minimum. On the mean of the nine months, the fall from 10 hrs. to 16 hrs. was ·0895, and ·0957 between the even hours of maximum and minimum. In other respects, too, the curve is characteristically continental. The fall of the night tide is almost evanescent, and the ratio of the co-efficient U' to U'', in the interpolation formula, is not less than 1·6 : 1* on the mean of the nine months, and in June and July 2·3 : 1. One other peculiarity worthy of notice is the range in the epoch of the morning maximum at different seasons. On the average of the four winter months, this falls at about 9 hrs. 31 min.; on that of June and July about 7 hrs. 35 min., or nearly two hours earlier. The time of the afternoon minimum varies less than an hour between the means of winter and summer, or between 15 hrs. 33 min. and 16 hrs. 11 min. approximately. Thus the interval between these extremes varies from about 6 hours to 8 hours 36 minutes. On the means of the individual months, the range both in the amplitude of the oscillation and of the time occupied, will, of course, be still greater.

I have elsewhere pointed out, what is indeed sufficiently obvious, that both these characters depend on the relative magnitude of the oscillations of single and double period, of which the whole phenomenon may be considered as made up; and I have adduced some reasons for regarding the major portion of the single oscillation as the effect of an actual oscillatory movement of a portion of the atmosphere between the land and sea; or, in the case of Yarkand and other stations near great mountain ranges, between the plains and the mountains. Also, it may be, in part between lower and higher latitudes. But this is a subject on which I shall not enter further in this place.

Diurnal variation of vapour tension.—The following are the co-efficients of Bessel's formula for the diurnal variation of vapour tension, computed, as in the case of pressure and temperature, from the hourly observations and six-hourly observations combined. The data are deduced from the observations of the dry and wet bulb thermometers, exposed to the free action of the air, under a shed, as described in the introductory portion of this paper; and the reduction has been made by August's formula, the readings of the instruments having been previously corrected for index errors at temperatures at and above the freezing point:—

	M	U'	u'	U''	u''	U'''	u'''	U''''	u''''
November to February ...	·088	·0146	208° 40′	·0017	55° 18′	·0031	322° 46′	·0079	270°. 0′
March to May ...	·168	·0072	255° 8′	·0121	211° 15′	·0029	34° 21′	·0062	4° 17′
June and July ...	·383	·0305	228° 48′	·0119	229° 0′	·0149	73° 18′	·0001	23° 9′
Nine Months ...	·180	·0144	226° 37′	·0053	212° 21′	·0041	46° 41′	·0239	8° 28′

* In a paper lately communicated to the Asiatic Society, I have pointed out that the varying magnitude of this ratio is a character distinctive of continental and oceanic curves.

The following Table gives the hourly values and variations computed by means of the formula and the curves are shown in Plate VIII :—

	November to February.		March to May.		June and July.		Nine Months.	
	Mean.	Variation.	Mean.	Variation.	Mean.	Variation.	Mean.	Variation.
Mid	·082	—·006	·157	—·011	·369	—·014	·170	—·010
1	·082	—·006	·159	—·009	·366	—·017	·170	—·010
2	·083	—·005	·156	—·012	·352	—·031	·167	—·013
3	·081	—·007	·151	—·017	·334	—·049	·160	—·020
4	·076	—·012	·150	—·018	·328	—·055	·157	—·023
5	·071	—·017	·157	—·011	·343	—·040	·161	—·019
6	·068	—·020	·171	+·003	·371	—·012	·171	—·009
7	·069	—·019	·184	+·016	·397	+·014	·182	+·002
8	·075	—·015	·189	+·021	·408	+·025	·188	+·008
9	·082	—·006	·184	+·016	·402	+·019	·188	+·008
10	·090	+·002	·176	+·008	·390	+·007	·186	+·006
11	·096	+·008	·169	+·001	·384	+·001	·184	+·004
Noon	·100	+·012	·167	—·001	·386	+·003	·185	+·005
13	·102	+·014	·167	—·001	·395	+·012	·188	+·008
14	·103	+·015	·166	—·002	·403	+·020	·189	+·009
15	·103	+·015	·163	—·005	·409	+·026	·189	+·009
16	·102	+·014	·163	—·005	·415	+·032	·191	+·011
17	·100	+·012	·170	+·002	·420	+·037	·193	+·013
18	·099	+·011	·179	+·011	·420	+.037	·196	+·016
19	·097	+·009	·185	+·017	·410	+·027	·195	+·015
20	·094	+·006	·182	+·014	·391	+·008	·189	+·009
21	·090	+·002	·171	+·003	·372	—·011	·179	—·001
22	·086	—·002	·161	—·007	·362	—·021	·172	—·008
23	·083	—·005	·156	—·012	·364	—·019	·169	—·011

These results show that, in the winter months, the diurnal variation of vapour tension is that characteristic of a damp atmosphere, *viz.*, increasing and decreasing directly with the temperature. However unexpected such a phenomenon may be on the border of a desert in the very heart of Asia, it is yet consistent with the result obtained from the general discussion of the registers in the previous part of this report, *viz.*, that the relative humidity of the air is at its maximum in the winter months, being as high as 84 per cent. of saturation in December. In the spring months, March to May, the rise of temperature being proportionally much greater than the rise of vapour tension, the relative humidity of the air reaches its (probable) annual minimum; and the diurnal vapour tension curve exhibits a depression in the middle of the day, which reaches its

lowest point between three and four in the afternoon; after which a rapid rise brings it to a second maximum between 7 and 8 in the evening. This evening maximum is, however, inferior to the morning maximum, which occurs about 8 A.M. In June and July, again, the relative humidity being higher than in the spring, the mid-day depression of the curve is less, relatively to the night depression, than in the spring months. But the whole oscillation is of much greater amplitude, and the absolute maximum of the vapour tension falls, in the evening, between 5 and 6 P.M. It is probable that these variations are not a little dependent on the diurnal variation of the winds.

DIURNAL VARIATION OF THE WINDS.—A much more extensive series of registers than are available for Yárkand would be required for anything like a complete discussion of this subject. But certain leading characteristics of the variation are of such regularity and relative importance, as to be exhibited prominently even in the means of the twenty-six days' hourly registers that are available, and in the wind observations recorded twice daily throughout the nine and half months of the Mission's residence in Káshghária.

In the first place, the total movement of the air, irrespective of direction, on the mean of the twenty-six days' hourly registration, exhibits three well-marked maxima and three minima in the twenty-four hours, and a fourth pair which are more doubtful. The first and least important of these maxima occurs a little after 2 A.M.; the second and more important a little after 9 A.M.: the third and apparently the chief maximum of the day would seem to occur at some time between half past 3 and 4, or perhaps somewhat later. Its exact period is somewhat doubtful, as the registers show a decrease in the movement between 4 and 5, which might possibly disappear in the means of more extensive materials. A fourth and somewhat doubtful maximum would seem to occur about half past eight. Inasmuch as three at least of these maxima occur about the times of maximum and minimum barometric pressure, there is an obvious probability that the two classes of phenomena are to a great extent the common effects of one and the same cause, but it would be futile to attempt any detailed discussion of the subject without more abundant data. The following table shows the mean movement of the wind during each hour of the day at Yárkand on twenty-six days between the 21st January and 28th July:—

Table showing the mean movement of the air in each hour of the day at Yárkand.

Hour.	Miles.	Hour.	Miles.	Hour.	Miles.	Hour.	Miles.
0 to 1	2·14	6 to 7	2·60	N to 13	2·63	18 to 19	2·34
1 to 2	2·32	7 to 8	2·80	13 to 14	2·28	19 to 20	1·81
2 to 3	2·85	8 to 9	2·91	14 to 15	2·92	20 to 21	2·45
3 to 4	2·02	9 to 10	3·09	15 to 16	3·38	21 to 22	2·26
4 to 5	2·00	10 to 11	2·25	16 to 17	2·53	22 to 23	2·
5 to 6	2·03	11 to N	2·60	17 to 18	3·15	23 to 24	2·20

With respect to direction the wind has a very decided tendency to blow from between west and north in the forenoon, and to change to east and south-east in the

evening. This is very perceptible in the hourly registers on simple inspection, and is shewn very decidedly in the following table of the observed directions of the wind-vane at 10 A.M. and 4 P.M.:—

WINDS OBSERVED AT 10 A.M.

MONTHS.	N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W.	N.W.	N.N.W.
October ...	...	...	1	...	4	...	...	...	...	...	1	...	5	...	2	...
November ...	...	3	8	...	2	...	...	...	...	...	...	...	11	...	3	3
December ...	6	2	2	2	2	1	...	...	...	...	...	1	1	...	1	10
January ...	1	1	1	...	...	4	1	...	1	...	2	1	5	4	3	1
February ...	...	...	...	...	1	...	1	...	1	1	1	...	12	6	3	2
March ...	2	...	...	1	...	1	1	1	1	3	1	2	4	5	6	3
April ...	...	1	...	...	...	1	2	...	1	1	2	...	2	7	8	5
May ...	...	...	...	...	...	2	3	1	...	...	...	...	6	3	11	5
June ...	1	2	1	...	...	...	1	1	2	...	...	1	2	8	7	4
July ...	2	...	1	...	1	...	...	2	...	...	...	...	2	2	7	12
TOTAL ...	12	9	14	3	10	9	9	5	6	5	7	5	50	35	51	45

WINDS OBSERVED AT 4 P.M.

MONTHS.	N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W.	N.W.	N.N.W.
October ...	1	...	...	...	4	...	...	...	...	...	...	...	5	...	3	...
November ...	...	1	2	1	10	...	1	...	...	...	...	...	11	...	3	1
December ...	6	5	3	5	1	...	...	...	...	...	...	...	3	...	...	5
January ...	2	2	3	9	1	4	1	...	...	...	...	...	...	...	2	1
February ...	2	2	3	4	3	3	7	1	...	...	...	...	...	...	2	1
March ...	2	3	4	...	...	2	9	2	...	...	...	...	3	2	3	1
April ...	2	1	2	2	1	2	4	1	3	...	...	1	2	2	5	2
May ...	1	...	...	...	1	1	5	1	2	1	...	...	2	5	11	1
June ...	1	2	...	...	...	...	4	6	1	...	...	...	4	5	5	2
July ...	4	2	...	...	...	...	2	2	1	...	...	...	1	3	9	4
TOTAL ...	21	18	17	21	21	12	33	13	7	1	...	1	31	17	43	18

But the character of the diurnal oscillation is still more distinctly shewn when the hourly observations of the wind-vane and anemometer on the twenty-six days are reduced to their hourly mean co-ordinates. And, perhaps, no single feature in the meteorology of Yárkand affords a more striking illustration of the paramount influence of purely local conditions, and of the extreme regularity of the march of the meteorological phenomena, then the fact that this diurnal variation of the wind stands out so distinctly in the

registers of so small a number of days taken at equal intervals through six and half months of the year. The following table gives the co-ordinates (north and east with a plus, and south and west with a minus sign;) first, as deduced directly from the observations, in which the position of the wind-vane at the hour of observation is assumed as that of the preceding hour; second, the corresponding values corrected by Bessel's formula, computed to four periodical terms; and lastly, the variation of the co-ordinates after deducting the mean diurnal resultant of the series. The curves that result from plotting these are given on Plate VIII:—

Table of mean wind co-ordinates for each hour of the day at Yárkand deduced from hourly observations of the wind-vane and anemometer on twenty-six days from January to July 1875.

Hours.	Wind movement in miles.					
	From observation.		Computed variation.		Computed movement.	
	N. + S. —	E. + W. —	N. + S. —	E. + W. —	N. + S. —	E. + W. —
Mid to 1 ...	+0·516	—1·226	—·1793	—·4722	+·6001	—1·4419
1 to 2 ...	+0·376	—1·547	—·0532	—·5283	+·7262	—1·4980
2 to 3 ...	+1·205	—2·099	+·0105	—·5751	+·8199	—1·5418
3 to 4 ...	+0·745	—1·483	+·0505	—·6129	+·8299	—1·5826
4 to 5 ...	+0·717	—1·450	—·0014	—·6239	+·7780	—1·5936
5 to 6 ...	+0·782	—1·569	—·0112	—·5880	+·7352	—1·5577
6 to 7 ...	+0·651	—1·230	—·0271	—·4974	+·7523	—1·4671
7 to 8 ...	+0·889	—1·403	+·0298	—·3188	+·8092	—1·3185
8 to 9 ...	+0·816	—1·090	+·0547	—·1335	+·8341	—1·1032
9 to 10 ...	+0·924	—0·894	—·0038	+·1552	+·7756	—·8145
10 to 11 ...	+0·310	—0·535	—·1198	+·4956	+·6596	—·4741
11 to Noon ...	+0·694	—0·071	—·2026	+·8151	+·5768	—·1546
Noon to 13 ...	+0·813	—0·126	—·1713	+1·0108	+·6081	+·0411
13 to 14 ...	+0·707	—0·220	—·0232	+1·0057	+·7562	+·0360
14 to 15 ...	+0·698	+0·342	+·1641	+·8053	+·9435	—·1644
15 to 16 ...	+1·216	—0·258	+·2949	+·5059	+1·0743	—·4638
16 to 17 ...	+1·103	—0·765	+·3238	+·2373	+1·1032	—·7324
17 to 18 ...	+1·098	—1·320	+·2710	+·0838	+1·0504	—·8859
18 to 19 ...	+0·873	—1·122	+·1825	+·0392	+·9619	—·9305
19 to 20 ...	+0·851	—0·502	+·0842	+·0298	+·8636	—·9399
20 to 21 ...	+0·798	—1·017	—·0265	—·0187	+·7529	—·9884
21 to 22 ...	+0·738	—1·328	—·1464	—·1286	+·6330	—1·0983
22 to 23 ...	+0·208	—1·141	—·2402	—·2674	+·5392	—1·2371
23 to Mid ...	+0·917	—1·188	—·2570	—·3889	+·5224	—1·3586

The co-efficients of the formula used for computing the corrected values are as follow :—

	M	U'	u'	U''	u''	U'''	u'''	U''''	u''''
N. and S. components ...	+·7794	·0996	225° 0'	·1771	314° 24'	·0748	62° 36'	·0625	308° 40'
E. and W. " ...	—·9697	·6799	245° 31'	·2515	97° 40'	·1236	263° 43'	·0396	30° 32'

Here it is clear that the resultant direction represented in the figures on Plate VIII by the lines A. B. is determined mainly by the winds of June and July, which are more steady and stronger than those of the winter months. This direction is parallel with the mountain range to the south of Yárkand. The diurnal variation, taking the corrected curve as our guide, consists of—1*st*, an oscillation to and from the mountains, the former being at its maximum between the time of maximum temperature and minimum pressure, the latter from midnight to sunrise; 2*nd*, an oscillation at right angles to this direction and parallel with the resultant, the wind being most south-easterly between noon and the time of maximum temperature, most north-westerly from three to five in the morning. This may, perhaps, also be regarded as an oscillation of the air to and from the mountains; since to the west of Káshghár the plain is quite shut in by the Pamir and the western extemity of the Thian-Shan. The wind curve displays some minor oscillations, among which it is very probable that the effects of the diurnal oscillations of pressure may be traceable; but it would be unsafe to base conclusions on the minor variations of a curve deduced from twenty-six days' observations only.

TABLES.

REDUCED AND CORRECTED REGISTERS OF METEOROLOGICAL OBSERVATIONS AT KÁSHGHÁR AND YÁRKAND.

TABLE I.

REDUCED AND CORRECTED DAILY REGISTER OF METEOROLOGICAL OBSERVATIONS AT KÁSHGHÁR AND YÁRKAND.

Observations at Yangi Shahr, Káshghár, October 1874.

Day of month.	Barometer reduced to 32°. 4 h.	10 h.	16 h.	22 h.	Mean.	Air Temperature. 4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Temperature of Radiation. Sun max.	Diff. sun and shade.	Min. Wool Rad.	Diff shade and Rad.	Wind. 10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19	26·001	26·016	25·914	25·937	25·967	38·0	49·5	65·6	47·1	50·0	72·2	34·6	37·6	100·5	34·3	?	?	E.	E.	...	...	...
20	25·896	25·877	25·609	25·695	25·702	39·0	45·4	62·6	48·6	48·9	71·0	34·3	36·7	127·0	56·0	28·5	5·8	N. E.	W.	...	...	...
21	25·683	25·671	25·647	25·769	25·687	52·1	63·6	57·9	45·6	54·8	65·7	47·0	18·7	105·0	59·3	30·5	7·5	E.	E.	...	...	...
22	25·736	25·739	25·761	25·898	25·783	46·1	56·0	51·1	51·1	52·0	57·8	40·8	17·0	77·5	19·7	?	?	E.	N.	...	...	...
23	25·895	25·997	25·959	26·050	25·975	43·1	49·1	55·6	39·5	46·6	58·9	34·4	24·5	111·5	52·6	?	?	W.	W.	...	...	...
24	26·011	26·021	25·909	25·983	25·988	35·0	42·1	52·6	39·0	42·2	56·3	30·3	26·0	102·8	46·5	26·3	4·0	E.	E.	...	...	...
25	25·970	25·975	25·873	25·917	25·941	32·5	42·6	50·1	37·8	40·8	53·3	30·0	23·3	99·0	45·7	23·0	7·0	W.	W.	...	...	...
26	25·989	26·036	26·015	26·160	26·050	32·5	41·5	46·1	39·5	39·9	50·8	30·0	20·8	96·2	45·4	25·5	4·5	S. W.	W.	...	...	...
27	26·218	26·337	26·301	26·313	26·300	38·5	38·0	43·5	39·0	39·7	44·5	35·6	8·9	83·5	39·0	29·8	5·9	N. W.	N. W.	...	...	...
28	26·208	26·323	26·224	26·190	26·259	30·0	39·8	40·1	34·0	39·0	50·1	35·1	15·0	95·0	44·9	?	?	W.	N. W.	...	...	...
29	26·115	26·120	26·051	26·176	26·115	30·0	42·1	40·1	30·5	39·4	53·1	26·0	27·1	104·0	50·9	22·0	4·0	W.	W.	...	...	...
30	26·114	26·173	26·103	26·101	26·145	29·0	42·1	48·6	38·8	39·6	53·5	27·8	25·7	103·5	49·0	21·7	6·1	W.	N. W.	...	...	...
31	26·146	26·180	26·108	26·104	26·157	31·5	42·1	50·4	35·2	39·8	54·6	27·7	26·9	104·3	49·6	19·5	8·2	N. W.	E.	...	...	...
Mean..	26·006	26·036	25·966	26·041	26·012	37·2	45·7	52·5	40·8	44·1	57·1	33·4	23·7	101·1	44·1	26·2	5·9	...	...	...	...	...

Day of Month.	Temperature of Evaporation.						Computed Vapour tension.						Relative Humidity.						Rain.	Cloud.		Beaufort's and cloud Initials.		
	4 h.	10 h.	16 h.	22 h.	Mean.	Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From min.	4 h.	10 h.	16 h.	22 h.	Mean.	From min.	Inches.	10 h.	16 h.	Before 10 h.	10 h. to 16 h.	After 16 h.
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19	33·7	44·5	50·0	42·5	42·7	33·0	·144	·232	·184	·216	·194	·181	64	67	29	69	57	80	...	0	10	b	b c.s.	o
20	34·4	38·0	49·6	44·0	41·4	31·1	·145	·169	·178	·237	·152	·143	62	54	33	70	55	72	...	1	10	b	v c	o
21	44·0	50·5	45·7	38·5	44·7	40·7	·199	·213	·161	·150	·191	·184	51	37	35	51	44	57	...	7	10	b	b c x	o
22	37·4	43·8	44·3	37·0	40·0	35·1	·125	·134	·178	·083	·130	·140	40	31	43	21	34	55	...	10	10	o	o	o
23	34·4	39·6	44·5	33·0	37·8	29·3	·100	·114	·161	·115	·131	·112	30	31	39	62	42	57	...	0	0	b	b	b
24	31·4	35·2	42·7	34·2	35·9	27·0	·110	·129	·164	·112	·111	·124	69	47	41	60	53	73	...	0	0	b	b	b
25	29·9	36·4	41·6	37·4	35·3	27·6	·112	·144	·164	·111	·149	·125	77	53	46	61	59	75	...	0	0	b	b	b
26	29·9	36·0	39·0	35·0	35·0	27·0	·142	·150	·190	·173	·163	·125	77	61	57	71	64	75	...	0	0	e	e	e
27	34·0	33·9	36·4	34·0	35·0	31·1	·165	·151	·133	·150	·152	·130	71	63	49	67	63	62	...	10	10	o	c s	c s
28	31·4	32·4	37·0	30·9	33·1	30·6	·139	·100	·139	·144	·128	·127	62	40	41	73	55	61	...	10	10	o	c s	c s
29	27·0	35·1	40·2	32·2	33·8	...	·124	·125	·149	·126	·134	...	75	47	42	62	50	...	...	0	0	b	b	b
30	26·9	34·0	33·6	35·4	34·2	26·4	·127	·125	·137	·167	·129	·127	70	48	42	71	60	83	...	0	0	b	b	b
31	24·9	34·0	44·1	31·6	34·1	24·6	·135	·125	·150	·140	·139	·134	70	46	42	63	53	63	...	0	0	b	b	b
Mean...	32·7	38·1	42·5	35·8	37·3	30·6	·140	·147	·160	·128	·151	·139	65	49	42	62	54	71	...	3·39	1·01	...	...	...

TABLE I. (Continued).—*Observations at Yangi Shahr, Káshghár, November 1874.*

Day of month.	Barometer reduced to 32°. 4 h.	10 h.	16 h.	22 h.	Mean.	Air Temperature. 4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Temperature of Radiation. Sun max.	Diff. sun and shade.	Wool Rad.	Diff. shade and rad.	Wind. 10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	26·160	26·189	26·097	26·154	26·119	29·0	43·1	49·2	38·0	39·8	54·6	26·1	28·1	103·5	49·0	20·4	6·0	N. W.	E.	...	...	...
2	26·124	26·187	26·082	26·165	26·139	30·3	41·0	54·8	42·1	42·0	58·2	26·0	32·2	111·5	53·3	19·6	6·4	N. W.	W.	...	...	...
3	26·179	26·227	26·137	26·108	26·185	30·3	45·6	54·1	39·8	41·7	57·2	36·8	20·4	110·5	53·3	33·2	3·6	W.	W.	...	...	...
4	26·181	26·204	26·101	26·114	26·150	31·0	45·0	52·8	35·0	41·0	57·4	27·1	30·3	109·1	51·7	21·9	5·2	W.	W.	...	...	...
5	26·049	26·044	25·912	25·941	25·994	28·8	42·8	51·1	38·0	40·2	57·1	26·5	30·6	109·5	52·4	22·1	4·4	W.	W.	...	...	...
6	25·889	25·916	25·868	25·970	25·911	30·0	46·1	50·4	38·0	40·9	59·6	26·2	33·4	120·5	60·0	21·1	5·1	W.	W.	...	...	...
7	26·013	26·094	26·016	26·135	26·072	30·0	40·7	48·1	32·2	37·7	54·3	26·1	28·2	110·5	56·2	19·0	7·1	W.	W.	...	...	...
8	26·161	26·182	26·085	26·077	26·120	29·0	39·5	42·1	29·0	34·9	47·0	24·0	23·0	95·3	47·4	18·3	5·2	W.	W.	...	...	...
9	26·036	26·039	25·976	25·972	26·006	25·5	36·0	42·6	30·3	33·6	48·2	23·5	24·7	105·0	56·8	17·2	6·3	W.	W.	...	...	...
10	26·019	26·069	26·076	26·064	26·057	27·0	37·3	40·0	32·5	34·2	45·0	24·8	20·2	87·5	42·5	17·1	7·7	W.	W.	...	...	...
11	26·047	26·113	26·048	26·097	26·076	27·5	37·5	44·9	31·0	35·2	50·4	25·2	25·2	108·0	57·6	18·7	6·5	W.	N. W.	...	...	...
12	26·071	26·125	26·066	26·191	26·113	23·8	39·5	46·8	32·5	35·7	52·8	21·5	31·3	109·5	56·7	11·9	6·6	W.	N. W.	...	...	...
13	26·211	26·313	26·235	26·248	26·259	21·6	40·0	45·1	29·8	34·8	53·0	23·0	29·6	109·0	56·4	17·0	6·0	W.	N. W.	...	...	...
14	26·233	26·236	26·163	26·187	26·205	25·0	37·0	46·4	30·0	34·6	53·1	23·1	30·0	109·0	55·0	16·5	6·6	E.	W.	...	...	...
15	26·122	26·139	25·993	26·123	26·094	24·0	40·5	46·1	29·0	34·9	52·0	21·0	31·0	108·8	56·8	14·0	7·0	E.	W.	...	...	...
16	26·089	26·125	26·071	26·092	26·094	24·6	36·8	44·6	29·0	34·3	52·5	22·5	30·0	108·5	56·0	17·0	5·5	N. W.	N. E.	...	...	...
17	26·060	26·103	26·002	26·058	26·058	25·8	38·9	46·4	29·1	35·1	52·4	23·0	29·4	107·5	55·1	17·5	5·5	N. N. W.	S. E.	...	...	...
18	26·011	26·029	25·976	26·010	26·016	23·8	30·5	45·7	29·0	34·5	52·9	21·0	31·9	110·5	57·6	14·9	6·1	N. E.	E.	...	...	...
19	26·035	26·070	25·966	25·962	26·008	23·2	39·9	45·1	28·9	34·1	52·5	21·1	31·4	107·2	54·7	16·0	6·1	N. E.	E.	...	...	...
20	25·867	25·832	25·723	25·734	25·789	23·0	38·0	48·1	31·3	35·1	54·7	19·0	35·7	110·5	55·8	11·9	7·1	N. N. E.	N. N. E.	...	...	...
21	25·675	25·681	25·613	25·811	25·703	30·9	51·7	61·6	35·0	44·5	70·6	26·5	44·1	124·2	53·6	20·0	6·5	N. E.	E. N. E.	...	...	...
22	25·925	26·069	26·000	26·170	26·002	28·0	32·0	32·6	26·0	29·7	49·9	29·0	20·9	81·5	31·6	22·8	3·2	N. N. W.	E.	...	...	...
23	26·210	26·252	26·134	26·143	26·185	24·9	25·1	27·0	24·0	25·3	31·5	21·0	10·5	52·0	20·5	18·7	2·3	N. E.	E.	...	...	...
24	26·105	26·174	26·206	26·315	26·208	20·0	22·0	27·0	20·0	22·3	30·9	15·5	15·4	71·5	40·6	0·5	6·0	N. E.	N. E.	...	...	...
25	26·473	26·573	26·550	26·564	26·540	18·5	20·8	23·0	17·8	20·0	26·6	14·5	12·1	59·3	32·7	12·6	1·9	N. E.	E.	...	...	...
26	26·511	26·469	26·344	26·316	26·410	14·0	20·0	23·4	17·0	18·6	27·7	12·2	15·5	68·5	38·8	7·9	4·3	N. E.	E.	...	...	...
27	26·231	26·210	26·165	26·155	26·198	13·2	19·1	24·5	16·5	18·3	29·7	10·1	18·6	73·5	44·8	4·9	5·3	N. N. E.	N. N. W.	...	...	...
28	26·101	26·116	26·027	26·041	26·071	12·0	20·0	27·0	18·0	19·2	30·3	11·0	19·3	78·0	47·7	5·5	5·5	N. N. E.	E.	...	...	...
29	26·065	26·040	25·999	26·069	26·043	17·0	21·8	26·0	22·0	21·9	33·2	13·5	19·7	81·5	48·3	7·0	6·5	N. N. W.	E.	...	...	...
30	26·060	26·097	26·032	26·080	26·067	17·0	23·0	31·0	21·0	23·0	35·9	13·0	22·9	83·7	47·8	8·9	4·1	N. E.	E.	...	...	...
Mean ...	26·099	26·132	26·060	26·108	26·100	25·0	35·4	41·3	29·0	32·7	47·6	21·7	25·9	97·4	49·8	16·2	5·5	...	...	...	...	...

Days of Month.	Temperature of Evaporation.						Computed Vapour Tension.						Relative Humidity.						Rain.	Cloud.		Beaufort's and Cloud Initials.		
	4 h.	10 h.	16 h.	22 h.	Mean.	Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Inches.	10 h.	16 h.	Before 10 h.	10 h. to 16 h.	After 16 h.
1	23·4	35·0	39·7	31·9	33·8	25·4	·110	·114	·114	·170	·120	·127	74	41	34	75	56	84	...	0	8	...	*b*	*m*. c.s.
2	29·6	34·0	43·0	36·4	35·7	24·9	·133	·137	·145	·150	·143	·124	83	53	31	56	56	89	...	9	0	...	*b* c	*b* c
3	26·3	36·0	42·8	32·0	37·2	33·0	·173	·125	·143	·110	·139	·102	75	40	30	44	49	74	...	0	0	...	*b*	*b*
4	27·0	36·0	41·0	32·4	31·7	25·5	·123	·130	·133	·154	·135	·122	71	43	34	77	56	82	...	0	3	...	*b*	*b* c
5	26·0	35·7	40·0	35·1	34·3	25·1	·113	·125	·123	·170	·133	·121	71	49	33	75	57	84	...	0	9	...	*b*	*m*. c.s.
6	26·7	36·4	40·8	32·7	34·1	23·1	·170	·116	·140	·125	·134	·120	69	39	41	56	51	69	...	1	10	...	*b* c.s.	*m*
7	23·4	32·6	37·4	28·3	31·7	23·5	·133	·091	·102	·114	·111	·100	85	38	30	63	54	71	...	0	0	...	*bb*	*b*
8	27·9	31·9	33·0	25·9	29·9	23·2	·143	·097	·106	·111	·114	·116	90	40	39	69	60	91	...	0	10	...	*b*	*m*
9	23·4	30·4	33·9	27·7	28·8	22·2	·104	·113	·100	·122	·110	·106	77	55	30	75	61	83	...	9	7	...	*b* c.s.	*b* c
10	24·9	31·9	33·7	29·9	30·1	23·6	·115	·122	·122	·142	·125	·114	79	53	51	77	65	85	...	10	10	...	*m*	oo
11	25·7	31·7	36·4	27·9	30·4	24·6	·117	·117	·119	·123	·110	·110	81	51	40	71	60	81	...	10	0	..	*m* x.s.	*b*
12	21·9	31·9	37·0	25·4	30·0	20·7	·093	·097	·130	·114	·110	·103	76	40	40	63	55	91	...	0	0	...	*bb*	*bb*
13	22·7	33·0	36·4	27·4	30·1	22·0	·101	·129	·100	·124	·114	·108	79	52	39	75	61	69	...	0	1	...	*bb*	*b* c.s.
14	22·9	32·1	36·0	26·0	29·7	22·1	·104	·125	·116	·117	·116	·108	77	57	36	70	60	88	...	9	4	...	*m* c.k.s.	*b*. c.s.
15	21·9	33·6	36·7	26·4	29·7	19·6	·098	·110	·111	·116	·109	·091	76	40	36	74	58	81	...	1	1	...	*bb* s	*bb* s
16	22·4	32·1	35·9	26·4	29·3	21·1	·103	·097	·116	·116	·108	·099	81	39	39	73	59	83	...	1	1	...	*bb* c.s.	*bb* s
17	21·0	32·1	36·6	26·4	29·8	21·6	·113	·106	·105	·116	·110	·101	60	44	34	72	57	82	...	3	1	...	*b* c.s.	*b* s
18	21·9	32·1	36·9	25·0	29·2	19·6	·093	·100	·125	·111	·109	·091	77	40	39	69	56	81	...	1	0	...	*bb* s	*bb*
19	21·9	32·1	36·4	25·9	29·1	20·0	·109	·094	·118	·119	·109	·097	65	38	39	75	59	86	...	0	0	...	*bb*	*bb*
20	21·4	31·9	33·8	25·9	29·5	17·9	·098	·114	·128	·089	·107	·069	60	50	39	49	54	65	...	1	1	...	*bb* s	*b* c.s.
21	33·4	41·5	39·0	30·0	35·4	24·0	·110	·114	·118	·135	·119	·104	49	30	30	66	46	73	...	1	4	...	*m* c.k.s.	*b* c.k.s.
22	26·9	25·9	30·4	24·4	26·9	24·9	·137	·082	·114	·114	·118	·124	89	45	77	82	73	88	...	10	10	...	*m*	*mm*
23	23·4	20·9	24·9	21·9	22·8	19·6	·108	·074	·115	·099	·099	·091	82	53	77	75	72	81	...	10	10	...	*m*	*m*
24	18·9	18·4	21·6	19·4	19·3	13·1	·063	·064	·091	·084	·076	·055	85	55	43	70	65	62	...	10	10	...	*m*	*m*
25	17·4	16·7	20·0	16·4	17·6	12·2	·084	·051	·079	·078	·073	·052	85	48	64	80	69	64	...	10	10	...	*m*	*m*
26	12·9	17·4	20·9	15·9	16·8	11·2	·069	·070	·088	·080	·077	·062	83	65	70	81	75	63	...	10	10	...	*m*	*m*
27	11·0	16·0	22·9	15·4	16·3	9·1	·065	·075	·103	·070	·081	·050	79	70	81	84	78	82	...	0	0	...	*b*	*b*
28	10·9	18·4	21·9	16·9	17·0	10·1	·062	·034	·069	·094	·075	·060	82	70	47	85	73	65	...	3	0	...	*b* s	*b*
29	15·9	19·4	22·9	19·4	19·4	12·1	·080	·081	·089	·078	·082	·061	84	69	60	67	70	77	...	3	4	...	*b* s	*m* c.k.s.
30	15·9	19·9	27·4	19·9	20·5	12·1	·080	·079	·113	·083	·089	·066	84	63	66	72	71	65	...	0	7	...	*b*	*b* c.k.s.
Mean...	23·0	29·4	33·6	26·1	28·0	20·3	·109	·102	·113	·114	·110	·099	79	50	45	71	61	82	...	3·73	4·37	...	...	...

TABLE I. (Continued).—*Observations at Yangi Shahr, Káshghár, December 1874.*

Day of Month.	Barometer reduced to 32°. 4 h.	10 h.	16 h.	22 h.	Mean.	Air Temperature. 4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Temperature of Radiation. Sun max.	Diff. sun and shade	Wool Rad.	Diff. shade and rad	Wind. 10 h.	16 h.	10 h. Miles.	16 h. Miles.	Total Miles.
1	26·061	26·067	25·998	26·035	26·041	15·0	25·0	30·0	21·0	22·8	35·9	12·8	23·1	60·0	41·1	8·5	4·3	N. N. E.	E.	...	...	...
2	25·998	26·012	25·970	25·975	25·990	10·0	20·0	32·2	22·0	21·8	35·0	17·5	17·5	70·0	35·0	12·0	5·5	N.	E. N. E.	...	...	...
3	25·962	26·034	25·964	25·976	25·984	18·5	25·5	32·9	21·0	24·5	37·3	15·5	21·8	81·5	41·2	10·1	5·4	N. N. W.	N. E.	...	...	...
4	25·951	26·052	26·012	26·069	26·028	19·0	26·5	32·6	30·0	27·0	36·8	19·0	17·8	73·8	37·0	14·0	5·0	E. N. E.	E. N. E.	...	...	...
5	26·092	26·154	26·124	26·156	26·131	26·0	32·0	35·3	29·5	31·2	39·1	21·0	16·1	83·6	41·5	?	?	N. N. W.	N.	...	...	...
6	26·114	26·164	26·060	26·050	26·101	27·5	28·5	32·0	28·0	29·0	34·2	25·3	8·9	52·7	18·5	19·3	5·5	N.	E. N. E.	...	...	...
7	26·003	26·058	25·935	26·091	26·034	21·0	27·0	38·0	23·3	27·3	42·0	17·8	24·2	94·0	52·0	14·3	3·5	N. N. W.	E. N. E.	...	...	...
8	26·128	26·190	26·162	26·220	26·175	16·0	24·2	34·0	20·0	24·1	37·7	12·9	24·8	91·5	53·8	8·8	4·1	E. S. E.	N. N. E.	...	...	...
9	26·201	26·227	26·104	26·077	26·202	14·7	26·8	34·0	22·0	24·4	38·9	12·3	26·6	89·3	50·4	8·5	3·8	N. N. W.	N.	...	...	...
10	26·073	26·079	25·998	26·005	26·030	17·5	29·0	34·9	27·0	26·8	40·0	14·6	25·4	94·5	54·5	10·4	4·3	E.	N. N. E.	...	...	...
11	25·969	25·953	26·011	25·932	25·940	17·0	28·5	38·5	25·0	27·2	43·0	15·0	28·0	99·0	55·1	11·6	4·3	N.	N. N. W.	...	...	...
12	25·874	25·887	25·779	25·862	25·850	19·0	29·0	43·8	26·0	29·2	47·1	18·0	29·1	99·5	51·4	13·1	4·0	W.	N. N. E.	...	...	...
13	25·823	25·894	25·836	25·872	25·856	21·3	31·0	35·2	24·2	27·9	40·1	17·5	22·6	76·0	34·9	12·1	5·4	N. E.	N.	...	...	...
14	25·843	25·904	25·854	25·892	25·871	19·8	29·0	41·0	20·0	23·7	46·0	16·0	30·0	104·3	58·3	11·2	4·8	W. S. W.	N.	...	...	...
15	25·871	25·937	25·878	25·952	25·909	19·0	31·8	37·5	29·0	29·1	45·5	16·9	28·6	100·0	54·5	11·1	5·8	N.	N. E.	...	...	...
16	25·957	26·214	25·959	26·001	26·033	21·5	27·5	36·0	27·0	28·0	41·7	18·5	23·2	87·5	45·8	13·1	5·4	N. N. W.	N. N. E.	...	...	...
17	25·956	25·999	25·925	25·955	25·959	19·0	25·0	32·0	23·0	24·9	35·1	16·6	18·5	55·5	20·4	12·6	4·0	N. N. W.	N.	...	...	...
18	25·901	25·901	25·823	25·861	25·869	14·5	34·0	49·6	23·8	30·5	53·8	12·5	41·3	100·3	52·5	6·6	5·9	N. N. W	W.	...	...	...
19	25·839	25·859	25·786	25·840	25·831	18·5	35·5	52·6	26·3	33·2	57·5	17·1	40·4	113·6	56·1	10·7	6·4	N. N. W.	W.	...	...	...
20	25·810	25·888	25·813	25·881	25·849	23·0	25·1	37·5	23·0	27·1	42·8	16·6	26·2	101·7	58·9	12·4	4·2	N. E.	N. N. W.	...	...	...
21	25·878	25·898	25·806	25·834	25·854	17·5	34·5	42·2	27·8	30·5	51·7	13·5	38·2	108·5	56·8	9·4	4·1	N.	N.	...	...	...
22	25·863	25·929	26·007	26·002	25·972	19·5	27·5	29·5	27·0	25·9	30·1	17·3	12·8	48·5	18·4	11·1	6·2	E. N. E.	N. N. W.	...	...	...
23	26·128	26·220	26·209	26·274	26·208	26·0	29·0	31·0	20·0	26·5	36·0	22·0	14·0	91·8	54·9	21·5	0.5	N. N. E.	N. N. W.	...	...	...
24	26·294	26·300	26·115	26·038	26·187	15·5	25·5	32·0	18·5	22·9	37·4	10·9	26·5	80·0	51·6	7·5	3·4	N. W.	N. N. W.	...	...	...
25	26·009	25·995	25·892	25·937	25·959	14·0	26·0	30·0	25·0	26·0	43·7	11·0	32·7	97·2	53·5	8·0	3·0	N. N. W.	W.	...	...	...
26	25·957	26·123	26·150	26·177	26·103	22·0	25·5	33·0	23·0	25·8	38·2	17·5	20·7	95·5	57·3	12·4	5·1	E.	N. N. E.	...	...	...
27	26·124	26·081	25·950	25·928	26·023	21·5	24·1	27·0	20·0	23·1	31·6	16·0	15·6	65·5	33·9	12·5	3·5	N. N. W.	E. N. E.	...	...	...
28	25·804	25·894	25·820	25·854	25·858	17·0	21·0	28·0	18·0	21·0	31·0	13·8	17·2	69·3	38·3	6·9	4·9	N.	N. E.	...	...	...
29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mean...	25·984	26·033	25·962	25·994	25·995	19·4	27·8	35·7	24·1	26·8	40·4	16·4	24·0	86·3	45·0	11·5	4·6	...	...	...	...	...

Day of month.	Temperature of Evaporation.						Computed Vapour Tension.						Relative Humidity.						Rain.	Cloud.		Beaufort's and Cloud Initials.		
	4 h.	10 h.	16 h.	23 h.	Mean.	Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From min.	4 h.	10 h.	16 h.	22 h.	Mean.	From min.	Inches.	10 h.	16 h.	Before 10 h.	10 h. to 16 h.	After 16 h.
1	13·0	21·0	29·0	17·0	20·1	11·7	·072	·089	·117	·069	·057	·062	83	65	70	60	69	82	...	0	7	...	b	b x.s.
2	16·0	22·0	27·4	18·0	21·5	16·0	·075	·098	·100	·074	·084	·083	72	63	57	62	64	88	...	1	3	...	b c	m c.x.s.
3	16·9	23·6	27·4	19·0	21·9	11·8	·080	·104	·093	·098	·094	·078	78	78	50	86	73	89	...	0	0	...	b	b
4	17·0	22·9	26·1	25·4	23·2	15·1	·089	·089	·092	·091	·098	·089	85	61	44	55	61	87	...	10	10	...	m	m
5	20·0	30·3	32·6	28·1	29·5	22·6	·137	·150	·154	·113	·110	·106	89	83	77	89	84	83	...	5	10	...	b c.x.s.	m
6	25·0	26·0	28·9	26·2	27·0	25·0	·126	·132	·130	·124	·128	·132	83	83	72	81	80	97	...	10	7	...	m	m c.x.s.
7	19·9	25·7	32·2	22·4	25·1	17·6	·093	·125	·135	·109	·117	·094	86	80	51	83	78	97	...	0	0	...	b	bb
8	16·9	22·0	27·1	16·0	21·0	12·2	·094	·103	·111	·093	·098	·069	85	81	57	85	77	87	...	0	0	...	b	bb
9	?	21·6	29·0	20·0	?	11·6	?	·100	·129	·103	?	·068	?	76	65	88	?	87	...	10	7	...	m	b c.x.s.
10	16·0	25·1	29·4	24·8	23·8	13·0	·076	·105	·100	·100	·099	·075	78	69	53	70	69	89	...	1	7	...	bb s.	b c.s.
11	15·0	25·4	32·4	23·1	24·3	15·0	·080	·105	·114	·108	·102	·077	84	69	50	81	71	89	..	0	6	...	bb	b c.x s.
12	17·9	24·4	35·2	24·0	25·0	17·1	·080	·095	·120	·125	·105	·085	85	54	44	89	69	87	...	2	4	...	b c.s.	b c.s.
13	19·0	28·4	30·1	22·0	25·3	16·7	·105	·129	·118	·113	·114	·095	82	75	59	85	75	67	...	0	10	...	b x.s.	o
14	19·4	25·4	36·3	24·4	25·0	15·1	·090	·110	·123	·114	·109	·077	81	73	49	82	72	80	...	0	5	...	m c.x.	b x.s
15	17·4	28·4	32·1	25·0	25·0	16·0	·080	·121	·123	·121	·111	·081	78	67	53	78	69	88	...	1	4	...	c s	m x.s.
16	20·3	24·0	31·9	24·0	25·5	17·6	·094	·110	·136	·115	·115	·087	83	73	64	77	74	80	...	10	10	...	b x.s.	o x s.
17	17·0	23·0	29·0	21·0	23·4	15·8	·089	·110	·117	·109	·113	·091	85	87	81	87	85	89	...	10	10	...	m	co
18	12·0	28·0	35·1	20·5	24·3	11·5	·061	·111	·044	·070	·075	·063	75	57	63	62	64	83	...	0	1	v c s.	v c s.	v c.s.
19	14·9	24·1	40·5	21·0	27·9	15·0	·053	·091	·213	·076	·113	·060	51	38	63	52	51	70	...	1	3	v c.s.	v s	c s.
20	18·0	21·9	31·7	20·1	23·1	14·6	·064	·089	·117	·070	·087	·065	51	64	51	65	57	70	...	1	1	v c.s.	v c.s.	b x s.c.
21	14·7	29·2	34·0	24·1	25·7	11·0	·055	·111	·125	·095	·097	·054	61	65	46	61	55	69	...	5	0	b	b c.x.	b c.x.s.
22	15·0	23·8	24·0	22·0	21·9	16·1	·050	·089	·091	·084	·080	·078	53	61	55	57	56	63	...	10	10	b c x.s.	o	co
23	22·4	27·0	24·0	17·1	22·1	20·1	·084	·080	·070	·065	·070	·089	60	59	44	60	53	70	...	0	0	m c.x s.	m c x.s.	b
24	13·0	22·4	28·0	14·0	19·6	10·0	·069	·089	·099	·052	·077	·059	70	65	54	81	62	85	...	0	0	b	b	b moonlight.
25	12·4	22·8	31·9	24·4	23·3	10·1	·060	·089	·105	·093	·087	·050	74	65	42	70	63	83	...	0	2	b	b	b x.s.
26	19·0	22·1	27·9	19·0	22·3	10·1	·074	·080	·104	·070	·087	·070	62	64	55	63	69	90	...	0	10	m	b	m
27	19·7	20·7	24·0	17·0	20·1	15·1	·071	·070	·084	·070	·079	·077	65	61	57	72	64	80	...	10	10	m	m	m
28	13·0	19·0	24·0	15·0	18·7	13·1	·053	·098	·105	·071	·083	·062	55	60	69	71	70	69	...	10	10	o		o
29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...
31	...	...	...	...	...	...	...	...	...	.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mean	17·0	24·7	30·1	21·9	24·0	15·1	·080	·103	·115	·095	·098	·074	74	69	57	73	67	81	...	4·32	5·57	...	...	...

TABLE I. (Continued).—*Observations at Yangi Shahr, Yárkand, January* 1875.

Day of month.	Barometer reduced to 32°. 4 h.	10 h.	16 h.	22 h.	Mean.	Air Temperature. 4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Temperature of radiation. Sun Max.	Diff. sun and shade.	Wool rad.	Diff. shade and rad.	Wind. 10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	25·818	25·834	25·716	25·724	25·780	10·2	22·8	31·0	21·5	23·6	32·0	17·8	14·8	90·5	57·0	6·3	11·5	E. S. E.	E. N. E.	...	...	...
8	25·750	25·816	25·863	25·975	25·858	18·0	23·0	31·0	20·0	23·0	37·3	15·0	22·3	101·0	63·7	4·0	11·0	W.	E. N. E.	...	...	...
9	26·057	26·133	26·062	26·085	26·084	15·5	22·0	34·0	23·0	23·6	36·6	11·0	25·6	100·5	63·0	—1·0	15·0	W. S. W.	E. N. E.	...	...	...
10	26·089	26·087	25·998	25·990	26·041	15·0	22·0	34·5	19·0	22·6	35·6	11·0	24·6	90·5	51·9	—2·9	13·9	E. S. E.	N. N. W.	...	...	...
11	26·004	26·033	26·020	26·110	26·042	14·0	20·3	34·0	20·5	22·2	33·9	9·0	24·9	88·6	54·7	?	?	S. W.	N. E.	...	10·1	...
12	26·167	26·260	26·129	26·185	26·183	14·5	18·0	28·0	22·0	20·6	31·0	7·2	23·8	82·8	51·8	—2·5	9·7	N. W.	N. N. E.	8·9	15·8	24·7
13	26·277	26·278	26·188	26·161	26·226	15·0	21·0	28·0	16·5	20·1	28·6	11·5	17·1	95·0	67·3	1·0	10·5	N. N. E.	E. S. E.	9·4	17·7	27·1
14	26·109	26·092	25·991	25·978	26·043	19·0	11·0	26·0	17·0	17·5	28·1	4·3	23·8	87·5	59·4	?	?	W. N. W.	N.	...	...	...
15	25·919	25·922	25·883	25·901	25·906	17·0	19·9	24·0	18·0	19·8	25·6	13·9	11·7	70·3	44·6	4·5	9·4	N.	N.	31·0	13·4	44·4
16	25·928	26·021	25·994	26·050	25·998	17·0	19·2	29·0	21·5	21·7	31·0	13·8	17·2	87·5	56·5	6·0	7·8	W. N. W.	N. W.	3·9	15·6	19·5
17	26·033	26·062	26·005	26·049	26·037	20·0	23·0	29·0	18·0	22·5	31·3	10·0	12·3	103·0	71·7	8·1	10·9	N. N. W.	N. W.	15·4	11·3	26·7
18	26·071	26·128	26·070	26·120	26·097	13·0	17·0	18·0	20·0	17·0	31·3	7·5	23·8	96·5	65·2	—2·8	10·3	W.	N. E.	22·3	14·3	36·5
19	26·121	26·107	26·130	26·182	26·150	10·0	21·0	29·0	16·0	21·2	31·6	15·5	16·1	92·5	60·9	11·7	3·8	E. S. E.	S. E.	16·8	15·5	32·3
20	26·109	26·215	26·187	26·191	26·195	10·0	17·0	29·0	18·9	19·7	31·3	2·0	29·3	91·3	59·9	—7·8	9·8	N. W.	E. N. E.	12·5	9·2	21·7
21	26·211	26·211	26·111	26·127	26·165	18·2	20·5	26·5	18·0	21·3	30·3	8·0	22·3	91·0	60·7	0·2	7·8	S. W.	E.	18·0	18·3	36·3
22	26·080	26·054	25·950	25·971	26·015	16·0	22·5	28·0	20·0	21·6	31·1	14·5	16·6	98·5	67·4	9·2	5·3	E. S. E.	N. N. E.	15·5	9·9	25·4
23	25·958	26·065	26·003	26·187	26·068	17·0	22·0	31·0	19·0	22·3	32·3	16·0	16·3	74·5	42·2	10·2	5·8	W. N. W.	E. S. E.	9·3	19·2	28·5
24	26·256	26·333	26·295	26·303	26·297	11·0	17·0	31·0	18·5	19·4	33·6	4·3	29·3	96·0	62·4	—3·8	8·1	N. W.	E. N. E.	16·4	13·9	30·3
25	26·288	26·266	26·147	26·200	26·225	10·0	24·0	32·0	16·5	20·4	35·0	4·9	30·1	99·0	64·0	—3·3	8·2	N. E.	E. N. E.	11·1	12·0	23·1
26	26·212	26·251	26·236	26·320	26·255	10·5	23·0	37·0	19·5	22·5	37·7	7·0	30·7	102·5	64·8	—1·3	11·3	S. E.	E. N. E.	11·3	12·5	23·7
27	26·360	26·408	26·358	26·412	26·380	11·0	23·0	31·5	17·5	20·7	33·9	4·9	29·0	99·5	65·6	—1·3	6·3	W. N. W	E. N. E.	26·2	13·6	39·8
28	26·381	26·300	26·284	26·271	26·333	14·0	19·0	29·0	17·0	19·8	32·6	11·0	21·6	96·0	63·4	2·7	8·3	W.	E. S. E.	29·8	18·4	48·2
29	26·214	26·214	26·143	26·200	26·193	10·5	20·0	31·0	17·0	19·6	?	2·5	?	96·5	...	—2·3	4·8	S.	E. S. E.	6·9	12·6	19·5
30	26·218	26·240	26·104	26·229	26·213	9·0	22·5	32·0	16·5	20·0	?	3·0	?	101·2	...	—0·5	0·5	W.	E. N. E.	11·9	13·9	25·8
31	26·235	26·283	26·194	26·166	26·220	9·5	21·5	33·0	16·0	20·8	?	—5·0	?	100·6	...	—1·8	0·8	W.	N. E.	11·3	12·6	23·9
Mean...	26·117	26·153	26·088	26·123	26·120	14·3	20·7	29·0	18·7	20·9	32·4	9·6	22·0	93·3	60·1	0·8	9·1	...	...	16·1	14·0	29·3

Day of month.	Temperature of evaporation. 4 h.	10 h.	16 h.	22 h.	Mean.	Min.	Computed vapour tension. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Relative humidity. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Rain. Inches.	Clouds. 10 h.	16 h.	Beaufort's and cloud initials. Before 10 h.	10 h. to 16 h.	After 16 h.
1	...		...	...	...		...	...		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4			...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	16·9	17·7	21·9	17·9	17·8	16·1	·075	·073	·079	·064	·072	·074	79	63	44	55	58	77	...	10	10	o	o	o
8	15·9	14·9	21·9	16·7	17·1	12·9	·071	·064	·053	·061	·064	·065	71	81	44	57	55	67	...	10	10	o	o	o
9	12·9	18·9	23·3	13·9	17·4	9·6	·076	·073	·124	·079	·081	·051	60	62	65	65	63	75	...	3	7	b c m.	b m.	b x m.
10	12·0	15·9	27·2	15·9	18·7	9·3	·059	·073	·074	·061	·064	·050	67	62	34	54	59	70	...	0	0	b	b	b
11	11·9	16·9	22·9	16·9	14·9	7·6	·055	·063	·128	·060	·076	·047	64	58	63	54	60	73	...	0	0	b	b	b
12	11·4	15·4	22·4	18·9	17·3	8·9	·042	·062	·073	·073	·061	·044	50	63	53	62	56	71	...	10	10	o	o	o
13	12·9	14·9	21·4	14·9	17·5	11·1	·059	·063	·079	·072	·073	·057	67	72	52	77	67	77	...	3	3	b	b x. s.	b c s.
14	13·9	12·9	21·9	14·9	15·2	3·5	·052	·064	·079	·067	·063	·043	65	83	55	71	64	82	...	0	5	b	b	b x s.
15	14·9	17·9	20·9	15·4	17·3	12·8	·057	·079	·064	·072	·073	·061	73	73	55	63	64	73	...	10	10	m	m	m
16	14·9	16·7	24·4	14·4	19·6	13·3	·067	·073	·065	·069	·074	·075	70	69	54	60	63	62	...	10	7	o	o	b x. s.
17	17·9	19·9	23·9	14·9	19·2	17·6	·079	·079	·050	·057	·071	·063	72	63	50	57	60	80	...	0	10	b	b	o
18	19·9	14·9	14·9	17·9	18·6	6·2	·055	·067	·057	·079	·064	·044	65	70	57	72	66	74	...	1	2	b	b s.	b. c. x. s.
19	15·9	17·9	23·9	13·9	17·9	16·1	·061	·063	·060	·059	·073	·064	54	60	53	70	59	73	...	2	0	b	b c. s.	b
20	7·9	15·4	23·9	15·4	15·7	6·6	·043	·072	·061	·052	·062	·031	61	77	50	51	60	61	...	2	0	b	b c. s.	b
21	11·9	17·1	23·9	14·9	17·1	6·3	·057	·063	·069	·057	·061	·043	53	59	44	57	53	70	...	0	0	b	b	b
22	13·4	15·9	22·4	11·9	12·7	13·1	·054	·069	·064	·051	·049	·054	60	58	44	47	52	79	...	1	10	b	b c. x.	o
23	14·9	19·4	24·9	14·9	14·5	14·8	·067	·073	·076	·047	·067	·071	70	67	44	45	56	79	...	10	10	o	o	o
24	9·9	14·9	21·9	14·9	15·9	3·0	·044	·067	·078	·053	·069	·037	63	70	44	51	57	70	...	0	0	b	bb	bb
25	7·9	20·9	25·9	12·9	16·9	3·1	·043	·064	·062	·054	·066	·032	61	64	45	60	55	60	...	0	0	b	b	b
26	5·4	15·9	23·9	15·9	15·3	5·6	·043	·061	·064	·054	·055	·042	61	51	45	52	52	71	...	0	0	b	b	b
27	6·9	12·8	25·9	13·9	17·1	4·1	·043	·074	·067	·044	·064	·044	68	62	40	49	55	62	...	0	0	b	b	b
28	11·4	18·4	21·9	13·9	16·7	10·0	·047	·069	·093	·053	·065	·029	57	64	60	55	59	53	...	2	7	b	b c.	b c. x. s.
29	5·1	16·9	23·9	13·0	15·7	1·2	·040	·063	·060	·053	·054	·033	57	59	34	55	51	69	...	0	0	b	b	b
30	6·9	17·4	24·9	13·4	16·2	1·6	·040	·074	·068	·043	·057	·033	60	62	36	53	53	64	...	0	0	b	o	o
31	7·4	20·2	25·9	12·4	16·6	3·3	·040	·070	·072	·040	·059	·074	60	59	34	45	50	62	...	0	0	b	bb	bb
Mean	11·9	17·9	21·6	15·6	17·5	9·3	·054	·071	·081	·059	·063	·052	63	61	40	53	58	74	...	2·58	4·01			

TABLE I. (Continued).—*Observations at Yangi Shahr, Yárkand, February* 1875.

Day of month.	Barometer reduced to 32°.					Air Temperature.								Temperature of Radiation.				Wind.				
	4 h.	10 h.	16 h.	22 h.	Mean.	4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Sun max.	Diff. sun and shade	Wool Rad.	Diff. shade and rad	10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	26·100	26·098	25·978	25·984	26·037	10·2	22·0	32·0	23·0	21·8	...	6·5	...	99·5	...	−2·5	9·0	S. W.	E.	8·9	12·0	20·9
2	25·916	26·001	25·957	26·007	25·978	13·0	24·5	34·0	17·5	22·0	...	7·2	...	101·5	...	−1·8	9·0	W. N. W.	S. E.	9·8	10·4	20·2
3	26·007	26·077	26·024	26·057	26·019	14·5	25·0	35·0	26·0	25·1	...	11·8	...	102·5	...	4·7	7·1	S.	S. S. E.	7·9	11·9	19·8
4	26·093	26·134	26·028	26·021	26·069	20·0	27·8	33·5	19·5	25·2	...	16·3	...	62·0	...	14·1	2·2	N. W.	S. E.	27·8	9·9	37·7
5	25·998	26·008	27·909	25·923	25·950	13·0	29·0	40·0	22·0	26·0	...	10·0	·	107·8	...	−1·0	11·0	W. N. W.	E.	9·9	12·5	22·4
6	25·955	25·983	25·898	25·912	25·937	15·0	28·0	41·0	21·5	26·4	...	12·0	...	103·6	...	7·0	5·0	W.	E. N. E.	27·4	18·2	15·6
7	25·902	25·945	25·858	25·916	25·905	14·0	32·5	43·1	27·0	29·2	...	11·2	...	106·5	...	1·8	0·4	W.	E. S. E.	11·9	12·4	24·3
8	25·990	26·036	26·018	26·061	26·026	16·0	27·0	34·0	25·0	25·5	...	12·0	...	88·2	...	8·7	3·3	W.	N. W.	33·8	24·4	58·2
9	26·055	26·079	26·009	26·058	26·050	18·0	26·0	38·0	25·0	26·8	...	12·0	...	95·0	...	11·2	0·8	W.	E. N. E.	10·3	14·2	24·5
10	26·014	26·072	26·039	26·115	26·068	23·0	32·0	37·0	25·0	29·2	...	17·9	...	100·5	...	11·4	6·5	W.	E. S. E.	14·4	12·1	26·5
11	26·159	26·209	26·120	26·187	26·170	19·0	30·0	36·0	25·3	27·6	...	14·9	...	98·5	...	8·1	6·8	N. N. W.	N. E.	27·1	15·4	12·5
12	26·171	26·219	26·112	26·154	26·164	13·0	30·0	38·8	24·5	26·1	...	11·8	...	101·5	...	5·3	6·5	W.	E. N. E.	13·6	12·2	25·8
13	26·184	26·209	26·137	26·100	26·167	16·0	29·5	38·0	21·5	26·2	...	11·8	...	100·5	...	9·1	2·7	N. W.	N. N. E.	27·3	7·1	34·4
14	26·126	26·110	25·993	25·991	26·055	15·8	27·0	37·0	23·0	25·7	...	14·0	...	102·5	...	7·2	6·8	W. N. W.	N.	17·0	12·0	29·0
15	25·917	25·904	25·898	25·911	25·900	22·0	30·5	35·0	25·9	28·3	...	21·4	...	98·2	...	14·2	7·2	W.	S. E.	14·1	12·6	26·7
16	25·861	25·862	25·772	25·820	25·826	21·5	34·0	39·0	24·5	29·8	...	17·1	...	101·5	...	9·5	7·6	W.	S. E.	36·3	24·2	60·5
17	25·704	25·767	25·701	25·795	25·764	16·0	32·0	40·0	31·0	29·8	...	13·9	...	105·5	...	?	?	W.	S. E.	18·5	16·8	34·3
18	25·842	25·997	25·991	26·085	25·979	24·0	34·0	39·0	34·0	32·7	...	21·9	...	95·0	...	17·4	4·5	W. N. W.	N. W.	24·2	16·9	41·1
19	26·050	26·118	26·009	26·020	26·051	29·0	40·0	45·4	32·0	36·5	...	27·1	...	110·0	...	22·5	4·0	W.	S. E.	24·5	17·9	42·4
20	25·999	25·987	25·931	26·083	25·975	21·0	37·0	45·1	29·0	33·0	...	19·0	...	110·5	...	15·5	3·5	N. W.	N. E.	30·3	18·1	48·4
21	25·925	25·993	25·893	25·910	25·930	21·0	36·5	40·1	31·5	33·8	...	18·0	...	111·8	...	9·0	0·0	W. N. W.	E. N. E.	22·6	18·2	40·8
22	25·803	25·898	25·838	25·894	25·871	30·0	34·0	39·0	31·0	33·5	...	28·5	...	62·5	...	24·9	3·0	W.	N. N. W.	25·9	3·0	28·9
23	25·900	25·982	25·906	25·987	25·944	26·0	42·6	51·6	33·0	38·3	...	20·7	...	116·5	...	?	?	W.	E.	23·5	15·1	38·6
24	26·004	26·054	25·960	26·029	26·011	24·0	39·0	48·1	33·0	36·0	...	21·5	...	110·5	...	16·0	3·5	W. N. W.	N.	37·2	26·0	63·2
25	26·020	26·063	25·963	26·032	26·019	28·0	48·1	55·0	35·0	41·7	...	23·9	...	119·5	...	14·0	9·9	S. S. W.	S. E.	26·9	13·2	40·1
26	26·024	26·020	25·878	25·860	25·948	26·0	45·1	56·1	35·0	40·6	...	21·9	...	120·5	...	14·0	7·9	N. N. W.	N. N. E.	32·7	11·9	44·6
27	25·830	25·822	25·713	25·834	25·800	28·0	51·1	61·6	41·0	45·4	...	25·2	...	128·8	...	15·0	10·2	S. E.	E. S. E.	22·8	16·2	39·0
28	25·920	26·123	26·150	26·296	26·124	36·0	47·1	54·1	36·5	43·4	...	31·0	...	119·8	...	26·0	5·0	E.	N. E.	37·0	18·2	55·2
Mean...	25·987	26·027	25·953	26·002	25·993	20·5	33·6	41·8	27·8	30·9	...	17·2	...	102·9	...	10·0	6·3	...	...	23·3	14·7	37·0

Day of month.	Temperature of evaporation. 4 h.	10 h.	16 h.	22 h.	Mean.	Min.	Computed vapour tension. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.
1	7·0	18·9	24·9	19·4	17·8	4·0	·013	·073	·093	·069	·043	·015
2	0·0	19·0	27·0	13·4	17·8	5·6	·039	·074	·094	·039	·062	·010
3	11·0	19·0	28·0	21·0	20·0	10·0	·050	·059	·101	·070	·072	·063
4	16·0	22·0	27·4	15·4	20·7	15·1	·065	·074	·083	·047	·069	·075
5	9·0	27·1	31·0	19·9	21·0	8·1	·039	·069	·091	·073	·063	·044
6	11·0	27·0	32·0	18·1	21·7	10·0	·015	·090	·079	·069	·075	·019
7	11·0	27·0	33·9	21·0	23·9	9·2	·055	·109	·075	·057	·084	·010
8	12·0	22·0	28·0	19·0	21·1	10·1	·019	·094	·111	·059	·076	·050
9	14·0	21·0	27·0	20·0	21·4	11·3	·057	·070	·054	·074	·076	·064
10	18·0	25·9	29·0	19·0	23·7	15·6	·064	·082	·098	·059	·076	·067
11	14·0	31·0	26·0	19·0	21·7	12·5	·047	·080	·058	·150	·072	·053
12	9·0	23·0	30·0	18·0	21·1	0·6	·039	·070	·115	·061	·072	·015
13	12·0	23·8	31·0	17·0	21·0	0·6	·019	·069	·114	·091	·074	·015
14	12·4	21·0	27·0	18·0	20·3	11·6	·044	·069	·064	·064	·060	·019
15	17·0	24·9	25·0	20·0	22·1	20·4	·059	·081	·052	·061	·084	·097
16	17·4	27·0	29·0	19·0	21·8	14·4	·055	·094	·078	·061	·073	·056
17	12·0	25·4	29·0	24·0	23·5	12·5	·019	·071	·085	·070	·070	·063
18	10·0	28·0	29·0	23·0	27·2	10·4	·079	·111	·078	·125	·097	·078
19	24·0	31·0	31·0	25·0	29·1	25·0	·036	·091	·073	·082	·066	·114
20	17·0	30·7	33·0	24·0	26·6	17·5	·069	·108	·073	·080	·081	·052
21	17·0	31·9	34·4	23·0	27·0	16·1	·069	·131	·067	·075	·081	·072
22	24·0	27·8	30·0	26·0	27·7	25·0	·068	·094	·095	·169	·090	·101
23	21·0	33·0	38·0	26·4	29·3	18·5	·079	·160	·098	·077	·089	·079
24	20·0	31·0	29·0	26·0	29·2	10·5	·044	·103	·097	·088	·093	·085
25	21·0	30·0	40·0	27·0	32·0	22·0	·105	·097	·094	·084	·095	·099
26	21·0	34·5	42·0	24·4	31·7	20·1	·079	·091	·109	·080	·092	·090
27	22·0	38·0	44·0	31·0	34·4	23·0	·074	·103	·091	·080	·087	·101
28	29·0	35·9	29·4	28·9	33·5	20·9	·108	·089	·075	·093	·090	·101
Mean...	16·0	27·1	32·3	22·0	24·9	15·1	·063	·083	·091	·073	·074	·070

Day of month.	Relative humidity. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Rain. Inches.	Cloud. 10 h.	16 h.	Beaufort's and Cloud Initials. Before 10 h.	10 h. to 16 h.	After 16 h.
1	58	62	30	50	53	60	...	10	9	o	o	o c.x.s.
2	49	58	49	40	48	67	...	7	7	b	b c.s	b c.x.s.
3	59	44	50	55	52	55	...	10	10	o	o	o
4	59	40	47	45	50	52	...	10	10	o	o	o
5	48	44	37	62	47	65	...	0	1	b	b	b c.s
6	51	58	39	57	51	60	...	7	5	b c s	b c s	b c s
7	66	59	34	47	52	65	...	9	2	b c s	b c s	b c s
8	53	67	57	44	52	68	...	9	10	b	b c s	o
9	57	55	24	54	48	58	...	10	5	o	o	b c s
10	41	45	45	44	46	67	...	5	9	b c.s	b c s	b s
11	45	51	27	40	40	62	...	0	0	b	b	b c.s
12	48	42	52	45	48	61	...	0	3	b	b	b c s
13	53	44	50	55	50	61	...	9	10	b x.s	b x.s	o
14	47	47	29	51	44	61	...	10	10	o	o	o
15	49	47	25	45	41	65	...	10	10	o	o	o
16	48	49	33	48	44	69	...	10	0	o	o	b
17	53	40	34	44	43	77	...	1	10	b	b s	m
18	53	67	24	65	51	68	...	10	10	m	m	m
19	60	37	24	45	42	77	...	0	2	b	b	b c s
20	60	50	24	50	46	70	...	0	10	b x.s	b x.s	o
21	60	60	21	31	43	74	...	10	10	o	o	o
22	51	48	40	62	50	64	...	10	10	o	o	o
23	65	36	25	42	39	71	...	1	2	b	b s	b c.s
24	64	43	24	47	40	74	...	2	10	b	b s	o
25	68	24	21	44	39	77	...	0	2	b	b	b c s
26	65	29	24	45	38	77	...	0	0	b	b	b
27	48	27	17	33	31	75	...	5	5	b c s	b c s	b c x s.
28	51	27	18	40	34	67	..	5	10	b	b x s	o
Mean...	54	46	34	48	45	70	...	6·00	6·24	...	...	...

TABLE I. (Continued).—*Observations at Yangi Shahr, Yárkand, March* 1875.

Day of month.	Barometer reduced to 32°.					Air Temperature.								Temperature of radiation.				Wind.				
	4 h.	10 h.	16 h.	22 h.	Mean.	4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range	Sun max.	Diff. sun and shade.	Wool Rad.	Diff. shade and Rad.	10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	26·330	26·370	26·250	26·220	26·299	30·5	40·0	46·1	35·0	37·9	...	27·8	...	101·0	...	24·9	2·0	W.	N. W.	43·1	22·0	66·0
2	26·183	26·142	25·990	26·008	26·082	27·5	45·1	49·1	38·0	39·9	...	26·0	...	108·2	...	20·5	5·5	S.	W.	39·0	12·5	51·1
3	25·932	25·943	25·805	25·769	25·862	28·5	44·1	52·6	40·0	41·3	...	27·0	...	117·5	...	21·2	5·8	W.	S. E.	14·5	12·3	26·8
4	25·777	25·790	25·676	25·710	25·738	31·0	50·1	52·6	40·0	43·4	...	28·0	...	101·0	...	22·8	5·2	S. S. W.	S. E.	17·2	12·1	29·3
5	25·711	25·714	25·677	25·717	25·705	32·0	54·1	62·6	43·1	47·9	...	29·8	...	127·5	...	20·2	9·0	E. N. E.	N. N. E.	25·0	20·7	45·7
6	25·711	25·730	25·604	25·815	25·716	39·0	49·1	52·1	46·1	46·6	...	32·5	...	106·2	...	29·2	3·3	N. W.	W. N. W.	42·5	47·8	90·3
7	25·811	25·867	25·702	25·719	25·775	43·0	62·1	64·1	43·1	53·1	...	30·0	...	116·3	...	30·5	8·5	S. S. W.	E. S. E.	60·7	14·7	75·4
8	25·750	25·802	25·745	25·809	25·777	39·0	54·0	61·1	48·1	50·7	...	34·6	...	131·0	...	30·8	3·8	N. W.	W. N. W.	59·2	28·2	87·4
9	25·811	25·805	25·690	25·759	25·765	39·0	61·1	62·1	45·9	52·0	...	35·3	...	132·8	...	27·0	8·3	S. S. W.	S. E.	46·0	9·0	55·0
10	25·818	25·833	25·763	25·800	25·803	36·5	53·1	57·1	46·1	48·2	...	34·6	...	124·8	...	31·7	2·9	W. N. W.	N. E.	43·3	24·0	67·3
11	25·762	25·703	25·551	25·574	25·648	38·5	50·1	52·6	45·1	46·6	...	36·6	...	106·0	...	33·2	3·4	N.	N. W.	28·1	10·8	47·9
12	25·668	25·760	25·722	25·717	25·724	43·1	45·1	53·1	40·0	45·3	...	39·7	...	103·2	...	38·8	0·9	S. W.	S. E.	71·5	11·3	82·8
13	25·713	25·844	25·789	25·823	25·800	36·5	50·1	48·1	43·1	44·5	...	32·9	...	98·0	...	29·6	3·3	N.	N.	50·9	26·4	77·3
14	25·823	25·806	25·766	25·913	25·832	37·5	51·1	45·3	40·0	43·5	...	34·1	...	125·5	...	30·5	3·6	W. S. W.	W.	42·8	49·3	92·1
15	25·966	26·025	25·970	26·019	25·995	37·0	52·1	57·6	45·1	47·9	...	33·5	...	122·0	...	27·9	5·6	S. S. E.	N. N. E.	69·4	16·3	85·7
16	26·029	26·004	25·997	26·063	26·016	36·5	54·6	61·1	48·1	50·1	...	33·3	...	124·0	...	32·5	0·8	W. N. W.	N. E.	38·4	13·6	52·0
17	26·115	26·174	26·072	26·149	26·127	41·0	54·1	62·1	45·6	50·7	...	37·3	...	126·5	...	34·0	3·3	W.	N. E.	54·7	15·5	70·2
18	26·139	26·221	26·104	26·157	26·155	37·5	60·1	66·6	45·6	52·4	...	34·2	...	132·5	...	29·5	4·6	N. W.	S. E.	28·0	17·3	45·3
19	26·109	26·113	25·991	26·047	26·065	39·0	63·1	68·1	50·0	55·1	...	34·1	...	133·2	...	30·9	3·2	N. N. W.	N. N. E.	25·2	17·3	42·5
20	26·053	26·071	25·924	25·993	26·010	38·2	62·1	69·6	48·1	54·5	...	36·1	...	134·5	...	31·9	4·2	N. W.	S. E.	39·4	18·6	58·0
21	25·949	26·008	25·918	26·003	25·984	39·0	67·6	71·1	55·1	58·2	...	35·6	...	138·0	...	29·8	5·8	N. N. W.	N. W.	26·0	17·2	43·2
22	26·043	26·104	25·916	25·965	26·014	44·1	64·6	67·1	52·1	57·0	...	41·7	...	133·2	...	34·6	7·1	E. S. E.	E. S. E.	20·7	27·9	48·6
23	25·917	25·889	25·722	25·741	25·817	42·1	67·1	71·1	51·1	57·9	...	39·0	...	135·5	...	32·0	7·0	W. N. W	S. E.	25·6	14·8	40·4
24	25·701	25·760	25·730	25·815	25·751	42·1	54·1	60·6	54·1	52·7	...	37·7	...	128·5	...	34·9	2·8	N. W.	W.	26·5	52·9	79·4
25	25·819	25·903	25·854	25·911	25·872	41·0	60·6	67·6	50·1	54·8	...	40·5	...	141·5	...	40·0	0·5	W.	N.	67·3	40·9	128·2
26	25·857	25·891	25·764	25·847	25·832	38·0	69·1	77·7	56·1	60·2	...	36·9	...	148·0	...	30·0	6·9	W. S. W.	N. N. W.	51·1	15·6	66·7
27	25·861	25·986	25·923	26·084	25·963	43·1	69·1	70·1	52·1	58·6	...	39·7	...	145·5	...	?	?	N. W.	N. E.	37·1	17·8	54·9
28	26·151	26·120	25·984	26·057	26·078	44·0	49·1	55·0	49·1	49·3	...	42·8	...	86·0	...	42·2	0·6	N. N. W.	S. E.	57·7	11·4	69·1
29	26·061	26·142	26·052	26·119	26·093	45·6	56·1	64·1	52·1	54·5	...	44·3	...	106·5	...	40·5	3·8	W. N. W.	S. S. E.	27·8	6·0	33·8
30	26·097	26·145	26·004	26·038	26·071	47·6	60·1	68·1	53·1	57·2	...	45·0	...	110·5	...	12·5	3·4	S. E.	S. S. E.	14·8	3·7	18·5
31	25·981	25·924	25·741	25·760	25·853	48·6	63·1	68·6	55·1	58·8	...	48·3	...	111·0	...	15·9	3·0	W. N. W.	S. E.	20·2	6·6	26·8
Mean...	25·925	25·958	25·856	25·910	25·912	39·9	56·0	60·8	47·0	50·7	...	38·1	...	121·2	...	31·6	4·3	...	...	39·8	20·1	59·9

Day of month.	Temperature of Evaporation.						Computed Vapour Tension.					
	4 h.	10 h.	14 h.	22 h.	Mean.	Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From Min.
1	23·1	31·9	37·1	28·9	30·5	21·6	·086	·091	·100	·101	·095	·100
2	22·9	35·0	38·0	31·9	31·9	22·4	·073	·171	·084	·111	·095	·083
3	23·9	35·9	37·4	31·4	32·6	23·6	·085	·122	·093	·090	·097	·093
4	25·9	39·9	38·9	32·9	34·4	25·5	·092	·135	·080	·110	·104	·113
5	25·4	41·4	43·0	32·9	36·4	25·1	·087	·110	·102	·077	·094	·089
6	27·9	35·4	39·4	35·9	35·4	27·6	·044	·111	·094	·100	·088	·102
7	32·9	45·0	44·0	31·9	38·5	30·0	·077	·107	·063	·058	·076	·094
8	28·9	40·4	43·0	35·9	37·0	27·1	·081	·089	·075	·074	·076	·073
9	30·9	44·0	45·0	35·7	38·9	29·6	·093	·096	·107	·091	·097	·107
10	30·9	42·0	43·5	35·9	38·3	30·1	·120	·143	·126	·119	·127	·123
11	32·4	40·0	40·4	35·0	37·3	31·6	·114	·135	·103	·111	·117	·125
12	37·4	35·9	49·4	31·9	37·2	34·6	·159	·111	·106	·149	·131	·144
13	32·4	43·0	41·5	35·9	38·0	31·3	·134	·199	·154	·193	·178	·106
14	36·4	44·0	49·0	35·4	39·0	33·3	·201	·209	·212	·213	·209	·152
15	34·4	47·0	45·0	37·4	40·0	32·6	·164	·170	·139	·156	·160	·175
16	32·4	45·5	45·0	39·9	41·4	31·8	·131	·197	·188	·157	·164	·170
17	37·9	45·5	47·0	39·4	42·5	35·2	·103	·203	·153	·171	·191	·194
19	32·1	47·9	48·5	37·0	41·5	30·2	·123	·157	·131	·130	·143	·130
19	32·9	49·0	49·0	38·7	42·4	30·2	·123	·189	·132	·104	·159	·130
20	32·9	47·8	49·0	37·9	41·9	31·4	·133	·162	·116	·117	·132	·129
21	32·4	49·5	50·0	40·9	43·2	30·3	·109	·143	·122	·099	·118	·117
22	36·0	46·0	49·5	35·4	41·9	35·2	·112	·101	·070	·077	·100	·133
23	34·4	49·5	50·5	40·9	43·8	32·3	·112	·119	·128	·144	·131	·109
24	34·9	41·1	45·5	40·7	40·6	31·1	·125	·116	·130	·101	·118	·109
25	31·9	50·0	48·0	38·9	42·2	30·6	·089	·211	·114	·115	·139	·072
26	32·9	53·6	55·1	45·0	47·9	31·2	·133	·270	·178	·244	·209	·118
27	37·4	61·1	63·4	47·5	52·1	32·4	·150	·415	·405	·272	·335	·102
28	37·9	35·9	45·5	40·0	40·8	34·3	·162	·126	·102	·167	·162	·102
29	39·9	45·0	51·5	44·0	44·9	37·5	·165	·175	·232	·199	·193	·149
30	41·4	50·0	55·6	46·0	48·2	39·7	·190	·247	·291	·231	·210	·175
31	42·5	53·5	49·0	44·0	46·9	39·7	·199	·294	·126	·121	·185	·138
Mean...	32·9	44·4	45·9	38·1	40·3	31·1	·125	·167	·145	·135	·143	·124

Day of month.	Relative Humidity.						Rain.	Clouds.		Beaufort's and Cloud Initials.		
	4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Inches.	10 h.	16 h.	Before 10 h.	10 h. to 16 h.	After 16 h.
1	47	37	33	59	41	63	...	10	10	o	o	o
2	52	36	24	50	40	60	...	0	10	b	b	o
3	54	41	23	57	39	63	...	10	10	o	o	o
4	53	26	21	44	35	73	...	8	10	b s	b s	o
5	49	24	18	27	30	54	...	10	10	o	o	o
6	29	31	25	31	27	54	...	10	10	o	o	o
7	24	10	11	20	20	40	...	0	5	b s	b k s.	b s
8	26	21	14	22	21	37	...	0	10	b	b	o
9	40	18	10	31	27	52	...	1	10	b s	b s	o
10	50	25	20	37	39	61	...	7	10	b k.s.	b k.s.	o
11	50	37	23	36	39	59	...	10	10	o	oo	oo
12	60	20	20	60	44	60	...	10	1	oo	oo	b k. s.
13	64	65	47	68	61	84	...	10	10	o	o	os
14	91	50	69	87	75	92	·01	1	10	b	b k.s.	o
15	78	45	33	45	60	91	·11	0	4	o	o	o s
16	64	49	35	46	49	85	...	0	0	bb	bb	bb
17	76	50	23	66	53	82	...	5	0	b s	b s	bb
19	53	37	22	45	39	65	...	0	0	bb	bb	bb
19	51	33	19	31	33	65	...	0	5	bb	bb	bb s
20	56	31	16	34	34	61	...	0	3	b k.s.	b k.s.	b s
21	40	23	16	22	27	57	...	0	7	bb	bb	b k. s.
22	49	17	14	19	25	59	...	0	10	b	b	oo
23	42	24	19	38	30	45	...	0	10	b	b	o
24	46	23	26	25	31	49	...	10	10	o	o	o
25	32	40	17	31	32	29	...	0	5	b	b	b s
26	58	41	19	54	43	74	...	7	3	b k.s.	b k.s.	b s
27	57	59	69	72	64	42	...	1	10	b	bb s	o
28	56	35	46	47	46	37	...	10	10	m m	m m	m m
29	53	39	40	51	46	50	...	10	10	m m	m m	m m
30	59	48	44	57	52	57	...	10	10	m m	m m	m m
31	60	53	19	28	40	44	...	10	10	m m	m m	m m
Mean...	52	37	29	43	40	59	·12	5·42	7·59	...	...	...

TABLE I. (Continued).—*Observations at Yangi Shahr, Yárkand, April* 1875.

Day of month.	Barometer reduced to 32°.					Air Temperature.								Temperature of Radiation.				Wind.				
	4 h.	10 h.	16 h.	22 h.	Mean.	4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Sun max.	Diff. sun and shade.	Wool Rad	Diff. shade and rad.	10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	25·873	25·735	25·625	25·751	25·690	48·1	70·1	75·7	59·1	63·3	...	46·2	...	138·5	...	42·6	3·6	S. E.	S.	22·0	19·0	41·0
2	25·900	25·810	25·713	25·851	25·807	52·1	74·1	75·2	57·1	64·6	...	50·5	...	145·2	...	46·2	4·3	W. N. W.	W. N. W	73·8	18·1	91·9
3	26·004	26·026	25·947	26·025	25·976	50·1	63·1	66·6	58·1	59·5	...	49·5	...	110·0	...	45·5	4·0	N. N. W.	N. N. W.	44·6	30·4	75·0
4	26·013	26·004	25·980	26·036	26·039	51·6	63·1	67·6	57·1	59·9	...	50·0	...	137·2	...	48·0	2·0	N. N. W.	N. E.	34·4	11·2	45·6
5	26·036	26·043	25·884	26·023	25·971	52·1	64·1	70·6	58·1	61·2	...	49·5	...	124·2	...	43·1	6·4	W. N. W.	N.	18·9	12·8	31·7
6	25·860	25·883	25·737	25·815	25·829	49·6	68·1	74·1	60·6	63·1	77·9	46·6	31·3	136·5	58·6	43·8	2·8	N. W.	S.	24·0	11·1	35·1
7	25·930	26·007	25·971	26·046	26·001	51·1	60·1	64·6	54·1	57·5	69·9	49·4	20·5	110·0	40·1	46·5	2·9	N. N. E.	N. N. E.	45·5	16·7	62·2
8	26·010	25·985	25·831	25·848	25·921	48·5	59·1	64·6	53·1	56·1	68·3	45·6	22·6	118·5	50·3	43·0	2·6	W. N. W.	N. N. W.	34·7	16·7	51·4
9	25·811	25·822	25·724	25·822	25·795	45·1	64·1	69·6	56·6	58·8	70·9	43·1	27·8	136·5	65·6	36·5	6·6	N. W.	N. W.	33·7	12·6	46·3
10	25·832	25·887	25·772	25·817	25·827	46·6	68·1	70·1	59·1	61·0	78·4	44·9	33·5	136·5	58·1	39·9	5·0	W. N. W.	N. W.	56·7	25·0	81·7
11	25·806	25·900	25·756	25·703	25·806	52·1	71·1	77·7	56·1	64·2	81·9	48·1	33·8	140·8	58·9	45·0	3·1	N. N. W.	S. E.	70·6	15·3	85·9
12	25·681	25·785	25·670	25·773	25·727	49·9	68·1	75·2	59·1	63·1	80·8	48·8	32·0	145·5	64·7	43·2	5·6	S. E.	N. E.	17·4	16·4	33·8
13	25·694	25·718	25·735	25·781	25·730	50·6	62·3	71·1	57·1	60·3	77·6	50·0	27·6	131·0	53·4	46·5	3·5	W. N. W.	W. N. W	44·0	41·4	85·2
14	25·796	25·823	25·777	25·865	25·815	56·6	70·6	73·6	54·6	63·9	75·5	54·4	21·1	124·5	49·0	49·5	4·9	N. N. W.	E.	67·8	16·4	84·2
15	25·862	25·907	25·820	25·906	25·874	51·1	69·6	77·1	63·1	65·2	81·4	49·9	31·5	136·5	55·1	43·5	6·4	N. W.	N. W.	35·8	21·8	57·6
16	25·925	25·974	25·891	25·952	25·936	60·1	70·1	71·1	53·1	63·6	77·5	59·3	18·2	122·0	44·5	58·4	0·9	W. N. W.	W.	84·5	32·5	117·0
17	25·932	25·978	25·864	25·909	25·921	49·1	71·2	79·2	59·1	65·4	82·5	46·0	36·5	145·5	63·0	35·1	10·9	N. W.	S. E.	28·0	13·5	41·5
18	25·929	26·008	25·907	25·959	25·950	51·6	73·1	80·0	59·1	65·9	84·6	49·1	35·5	147·5	62·9	43·1	6·0	N. N. W.	W. S. W.	21·5	12·3	33·8
19	25·975	26·012	25·917	25·984	25·990	52·1	74·1	81·2	60·6	67·0	85·4	50·0	35·4	141·5	56·1	45·3	4·7	N. W.	E. N. E.	26·5	11·3	37·8
20	25·965	26·001	25·883	25·908	25·939	52·6	77·2	85·0	59·0	68·5	89·6	50·0	39·6	145·5	55·9	41·2	8·8	W.	E. S. E.	22·9	7·9	30·8
21	25·895	25·923	25·772	25·802	25·848	52·6	82·2	87·7	61·1	70·9	89·6	49·1	40·5	151·5	61·9	36·1	13·0	N. W.	S. E.	24·9	12·7	37·6
22	25·795	25·824	25·671	25·718	25·752	51·0	82·2	89·2	62·1	71·1	92·9	49·5	43·4	154·5	61·6	37·5	12·0	W.	E. N. E.	20·7	11·7	32·4
23	25·747	25·803	25·716	25·875	25·785	63·1	83·7	81·7	70·1	74·7	89·4	58·3	31·1	148·5	59·1	44·6	13·7	N. W.	W.	77·7	55·7	133·4
24	25·908	25·934	25·789	25·822	25·863	60·9	80·2	81·4	67·1	72·4	87·6	58·0	29·6	144·5	56·9	53·4	4·6	S. S. W.	S. E.	103·2	14·8	118·0
25	25·894	26·001	25·824	25·870	25·897	56·1	63·1	69·3	61·1	62·4	74·2	53·6	20·6	120·5	46·3	52·5	1·1	W. N. W.	N.	30·7	15·8	46·5
26	25·818	25·861	25·836	26·006	25·880	58·1	68·1	70·6	60·1	64·2	73·6	56·9	16·7	115·5	41·9	54·6	2·3	N. W.	N. W.	13·3	15·2	28·5
27	26·012	26·096	26·069	26·121	26·075	59·1	62·1	65·1	60·6	61·7	72·3	57·3	14·9	110·5	38·3	56·3	1·0	S. W.	S.	76·3	32·5	108·8
28	26·115	26·130	26·029	26·030	26·080	52·1	69·1	71·6	54·6	61·9	77·4	52·0	25·4	137·5	60·1	47·5	4·5	S. W.	S. S. E.	26·6	13·9	40·5
29	26·007	26·004	25·904	25·959	25·968	49·1	74·6	78·2	57·1	64·8	83·2	45·5	37·7	147·5	64·3	36·0	9·5	E. S. E.	E. S. E.	7·7	13·4	21·1
30	26·017	26·077	25·948	25·980	26·015	52·1	71·6	78·2	63·1	66·2	82·9	50·0	32·9	140·2	57·3	44·9	5·1	S.	N. W.	34·5	11·2	45·7
Mean...	25·891	25·941	25·833	25·898	25·891	52·5	70·0	74·8	59·0	64·1	80·2	50·4	29·6	135·1	55·7	45·0	5·4	...	...	40·8	18·6	59·4

Day of month.	Temperature of Evaporation. 4 h.	10 h.	16 h.	22 h.	Mean.	Min.	Computed Vapour Tension. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.
1	35·3	51·3	55·0	47·3	47·0	34·2	·137	·161	·115	·152	·126	·131
2	37·9	52·0	55·0	43·3	47·1	35·7	·133	·139	·120	·126	·131	·102
3	47·4	44·0	53·3	45·0	45·0	34·7	·160	·165	·154	·175	·163	·123
4	42·0	48·3	49·8	45·0	46·5	42·2	·142	·170	·144	·164	·160	·141
5	42·0	50·0	50·3	43·0	46·3	41·3	·134	·172	·151	·152	·160	·172
6	37·4	50·3	53·8	45·0	47·2	32·1	·130	·172	·145	·124	·144	·125
7	37·4	45·0	47·0	47·1	42·0	29·2	·115	·130	·125	·095	·116	·120
8	32·9	41·3	49·3	41·1	41·2	26·2	·111	·130	·123	·125	·117	·107
9	37·4	47·0	49·2	42·0	43·6	32·3	·112	·130	·112	·113	·117	·123
10	37·4	50·0	49·7	41·9	43·6	26·3	·119	·134	·133	·130	·125	·114
11	37·1	51·0	55·3	45·9	47·2	28·7	·112	·147	·141	·135	·134	·129
12	42·3	50·0	52·0	45·0	47·2	41·2	·177	·159	·124	·141	·150	·174
13	42·0	47·5	51·0	41·5	46·3	41·2	·171	·150	·147	·147	·155	·160
14	44·0	52·0	51·3	41·3	44·1	47·3	·217	·177	·124	·122	·160	·124
15	37·3	51·3	53·8	46·0	46·1	40·8	·123	·102	·129	·105	·117	·110
16	47·0	53·0	53·3	41·0	47·9	47·3	·172	·139	·128	·154	·124	·101
17	37·7	52·0	52·1	47·0	47·0	35·7	·097	·124	·160	·157	·116	·113
18	41·5	52·0	55·1	47·0	47·7	40·1	·144	·140	·174	·157	·175	·123
19	42·5	52·5	54·5	47·5	49·2	37·7	·160	·143	·115	·175	·144	·153
20	42·0	53·1	57·0	45·3	49·2	41·3	·154	·163	·150	·210	·169	·162
21	47·1	57·3	57·1	46·5	50·9	47·5	·112	·164	·119	·109	·137	·135
22	41·1	53·1	54·9	46·9	51·4	40·5	·150	·209	·130	·174	·167	·151
23	47·2	59·1	57·1	50·0	51·6	45·8	·150	·192	·157	·133	·175	·166
24	40·3	51·9	57·9	51·0	53·9	45·3	·111	·157	·124	·122	·140	·130
25	41·1	47·0	52·5	45·0	47·2	39·5	·094	·142	·197	·154	·155	·093
26	40·5	50·0	51·0	43·0	47·1	40·1	·140	·159	·132	·223	·174	·107
27	47·5	50·5	53·5	44·5	47·4	47·2	·192	·237	·249	·190	·217	·211
28	40·9	53·5	51·5	47·5	50·6	40·3	·243	·224	·223	·243	·231	·251
29	42·5	57·9	55·0	46·5	50·4	41·1	·191	·275	·174	·192	·210	·208
30	43·0	52·8	51·5	45·0	47·6	41·5	·170	·175	·140	·165	·168	·163
Mean	42·1	51·4	52·9	45·2	48·1	41·1	·151	·167	·152	·164	·160	·150

Day of month.	Relative Humidity. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Rain. Inches.	Clouds. 10 h.	16 h.	Beaufort's and Cloud Initials. Before 10 h.	10 h. to 16 h.	After 16 h.
1	43	23	15	37	29	47	...	0	0	b	b	b
2	32	16	15	29	23	27	...	0	10	b	bb	o
3	29	29	25	39	32	43	...	10	10	m	mm	mm
4	47	31	21	35	34	50	...	10	10	mm	mm	mm
5	41	31	12	33	31	49	...	10	10	m	mm	mm
6	41	25	14	21	27	49	...	10	0	m	m	b
7	32	23	21	27	25	36	...	10	10	m	m	m
8	32	21	17	31	25	37	...	10	10	m	m	m
9	29	22	16	31	25	41	...	0	10	m	b	m
10	37	23	19	24	27	40	...	0	10	b	b	m
11	29	19	19	29	24	37	...	0	0	b	b	b
12	49	23	15	25	29	51	...	10	10	m	mm	m
13	43	20	19	35	33	44	...	10	10	m	mm	mm
14	33	21	16	45	29	37	...	10	10	m	mm	mm
15	32	25	11	29	25	41	...	9	10	b	b m. s.	mm
16	31	18	14	46	29	37	...	10	10	m	mm	mm
17	28	16	16	37	24	30	...	0	0	bb	bb	bb
18	21	19	17	37	31	44	...	10	0	m	mm	b
19	43	19	13	35	27	41	...	0	0	b	b	b
20	39	20	12	42	24	45	...	0	0	b	b	b
21	25	13	9	37	23	44	...	0	0	b	b	b
22	43	10	11	32	26	42	...	0	0	b	b	b
23	33	17	17	19	31	34	...	0	10	b	b	m
24	25	19	20	39	24	33	...	0	10	b	b	m
25	21	25	29	35	27	20	...	10	10	m	mm	mm
26	29	23	20	43	31	42	...	10	10	mm	mm	mm
27	49	43	41	39	41	45	...	10	10	mm	mm	mm
28	63	33	31	69	49	65	...	10	0	m	m	b
29	57	31	29	43	39	63	...	0	0	m	b	b
30	55	21	17	29	23	45	...	0	0	b	b	b
Mean	39	24	19	34	29	42	...	5·27	6·00			

TABLE I. (Continued).—*Observations at Yangi Shahr, Yárkand, May* 1875.

Day of month.	Barometer reduced to 32°.					Air Temperature.								Temperature of Radiation.				Wind.				
	4 h.	10 h.	16 h.	22 h.	Mean.	4 h	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Sun max.	Diff. sun and shade.	Wool rad.	Diff. shade and rad.	10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	25·919	25·957	25·824	25·861	25·898	49·6	74·1	78·3	63·1	66·3	87·8	49·1	38·7	146·5	58·7	38·2	10·9	N. W.	S. E.	37·6	16·3	53·9
2	25·860	25·862	25·715	25·820	25·823	51·3	83·7	87·2	65·6	71·9	91·2	55·4	35·8	150·5	59·3	17·0	8·4	W.	N. W.	54·8	46·1	100·9
3	25·869	25·890	25·810	25·810	25·853	59·1	83·2	87·2	65·1	73·7	93·3	57·9	35·4	154·0	60·7	48·6	9·3	W.	S.	52·8	21·0	73·8
4	25·927	25·798	25·668	25·774	25·760	53·6	85·2	84·7	73·1	74·2	92·5	62·7	30·8	164·5	72·0	40·4	12·3	N. N. W.	W. N. W.	25·2	12·3	37·5
5	25·785	25·781	25·657	25·780	25·751	63·1	85·2	86·2	69·1	75·9	92·6	60·3	32·3	153·0	60·4	55·3	6·0	N. W.	W. N. W.	111·7	19·9	131·6
6	25·709	25·769	25·695	25·801	25·766	61·1	82·2	77·7	69·1	72·5	89·9	59·6	30·3	149·0	58·1	54·3	6·3	E. S. E.	N. W.	53·6	20·0	73·6
7	25·813	25·759	25·727	25·915	25·803	56·6	78·7	69·1	59·1	65·9	84·4	55·4	29·0	149·0	64·0	46·3	9·1	E. S. E.	N. W.	72·1	27·9	100·0
8	25·923	25·915	25·814	25·871	25·881	49·6	73·1	69·1	63·1	63·7	78·4	48·3	30·1	143·0	64·6	43·9	1·4	N. W.	S. S. W.	143·5	13·9	157·4
9	25·901	25·923	25·924	25·959	25·903	51·6	66·6	70·1	62·1	62·6	77·4	49·5	27·9	139·0	61·6	45·9	3·6	N. W.	W. N. W.	33·7	14·3	48·0
10	25·935	25·938	25·844	25·910	25·909	56·1	73·1	71·1	62·1	64·1	80·0	48·5	31·5	151·5	71·5	37·0	11·5	N. W.	N. W.	42·3	11·0	53·3
11	25·889	25·806	25·675	25·733	25·776	60·6	74·1	71·9	70·1	66·7	82·6	49·6	33·0	148·5	65·9	40·6	0·0	S. S. E.	W. N. W.	36·5	16·7	53·2
12	25·764	25·837	25·809	25·907	25·829	53·1	67·1	67·6	65·1	63·3	74·9	54·2	20·7	136·5	61·6	50·0	4·2	W. N. W.	N. W.	89·7	31·2	120·9
13	25·959	26·032	26·012	26·007	26·018	56·1	64·1	69·1	57·1	59·3	66·4	55·4	11·0	125·0	58·6	63·4	2·0	N. W.	W.	95·3	33·4	128·7
14	26·053	26·116	26·115	26·189	26·118	50·1	49·5	48·1	45·1	48·2	50·3	47·0	3·3	71·5	24·2	47·5	0·0	S. E.	N. N. W.	56·5	14·1	70·6
15	26·136	26·169	26·115	26·108	26·139	42·0	56·1	63·1	50·1	53·0	66·5	41·7	24·8	133·5	67·0	36·9	4·8	S. E.	N. W.	27·4	15·2	42·6
16	26·053	26·000	25·972	25·983	26·010	38·5	67·1	74·1	51·1	57·7	75·9	36·6	39·3	139·0	63·1	28·0	8·6	W.	W.	28·8	6·3	35·1
17	25·955	25·989	25·902	25·956	25·951	43·1	75·2	81·2	55·1	63·6	84·2	41·7	42·5	145·5	61·3	31·5	10·2	W.	S. S. E.	17·2	10·4	27·6
18	25·971	26·022	25·913	25·932	25·959	50·1	79·2	87·2	61·1	70·2	92·1	46·0	46·1	150·5	58·1	33·9	12·1	W. N. W.	S. E.	13·1	12·0	25·1
19	25·924	25·966	25·775	25·933	25·899	54·6	86·2	92·3	65·1	74·6	95·4	53·0	42·4	156·5	61·1	44·4	8·6	N. W.	E.	23·6	17·3	40·9
20	25·909	25·932	25·786	25·816	25·861	54·1	81·2	92·8	68·1	74·0	95·6	52·4	43·2	161·0	65·4	40·8	11·6	N. N. W.	S. E.	9·1	12·7	21·8
21	25·790	25·809	25·657	25·717	25·715	58·1	88·2	96·3	75·2	79·5	98·4	55·6	42·8	161·5	63·1	43·6	12·0	N. W.	E. S. E.	26·3	11·7	38·0
22	25·734	25·694	25·613	25·783	25·706	69·6	99·2	88·0	76·2	80·7	96·2	65·2	31·0	157·5	61·3	62·5	2·7	N. W.	N. W.	80·3	25·0	105·3
23	25·776	25·780	25·702	25·819	25·769	69·1	85·2	90·2	79·2	80·9	94·2	65·2	29·0	152·5	58·3	62·9	2·3	W.	N. W.	232·8	39·8	272·6
24	25·812	25·837	25·720	25·752	25·780	71·6	74·1	77·2	72·1	73·8	79·4	67·5	11·9	?	?	?	?	N. W.	N. W.	16·4	2·0	18·4
25	25·731	25·720	25·601	25·629	25·670	67·6	79·7	83·7	73·1	76·0	89·4	66·9	22·5	130·0	40·6	61·7	2·2	N. W.	S. E.	14·2	3·2	17·4
26	25·653	25·698	25·707	25·759	25·704	62·1	77·7	79·2	70·1	72·3	82·2	64·1	18·1	113·0	36·3	56·2	7·9	W.	W. N. W.	56·6	55·0	111·6
27	25·785	25·852	25·822	25·924	25·846	67·6	81·2	89·2	72·1	76·0	89·4	63·1	26·3	152·5	63·1	58·3	4·8	S. E.	S. E.	65·0	4·2	69·2
28	25·947	25·930	25·812	25·816	25·884	65·1	78·2	83·0	71·1	74·3	88·4	63·7	24·7	135·2	46·8	61·6	2·1	N. N. W.	N.	39·0	6·2	45·2
29	25·770	25·752	25·604	25·609	25·694	62·6	79·7	85·2	77·1	76·2	91·4	61·2	30·2	111·0	49·6	55·6	5·6	N. N. W.	S.	13·2	4·3	17·5
30	25·530	25·641	25·703	25·795	25·682	61·1	76·2	69·6	68·1	69·2	79·4	62·4	17·0	122·5	43·1	53·3	9·1	N. N. W.	N. W.	2·6	85·7	88·3
31	25·783	25·781	25·715	25·855	25·783	62·6	75·2	81·7	65·1	71·2	87·1	59·8	27·3	118·5	61·4	53·9	5·9	W. N. W.	N. W.	205·6	56·3	261·9
Mean...	25·869	25·872	25·786	25·809	25·844	56·7	76·5	78·6	65·9	69·4	84·7	55·1	29·6	142·7	57·8	47·9	6·8	...	...	57·3	21·5	78·8

Day of month.	Temperature of Evaporation. 4 h.	10 h.	16 h.	22 h.	Mean.	Min.	Computed Vapour Tension. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Relative Humidity. 4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Rain. Inches.	Clouds. 10 h.	16 h.	Beaufort's and cloud Initials. Before 10 h.	10 h. to 16 h.	After 16 h.
1	42·5	56·1	57·0	50·0	51·0	42·3	·168	·215	·235	·213	·220	·193	55	29	26	37	37	55	...	0	10	*m*	*b*	*m*
2	45·0	57·1	59·1	49·5	52·8	45·2	·233	·169	·163	·166	·163	·180	60	14	14	28	20	43	...	0	0	*b*	*b*	*b*
3	45·0	57·1	58·6	50·0	52·7	45·1	·111	·169	·157	·100	·164	·155	28	15	14	31	22	32	...	0	0	*bb*	*bb*	*bb*
4	45·0	59·1	59·1	58·1	55·3	44·7	·203	·203	·209	·310	·231	·206	40	17	18	38	31	51	...	9	10	*o*	cs	*o*
5	49·5	58·1	56·1	49·0	53·2	48·4	·195	·175	·108	·120	·150	·205	35	15	9	17	19	38	...	0	5	*b*	*b*	*b* K.S.
6	47·5	59·1	56·1	53·0	53·9	46·3	·170	·238	·205	·220	·208	·161	33	22	22	31	27	32	...	10	10	*o*	*o*	*o*
7	48·0	58·6	49·0	42·0	49·4	48·3	·239	·255	·120	·076	·173	·250	52	27	17	15	28	59	...	0	10	*b*	*b*	*o*
8	38·4	50·1	50·0	46·0	46·1	37·1	·106	·099	·145	·118	·117	·095	29	12	20	21	20	29	...	0	10	*b*	*b*	*o*
9	44·0	52·0	52·5	49·8	49·6	42·2	·203	·223	·189	·224	·210	·186	53	34	27	30	38	53	...	10	10	*o*	*o*	*m*
10	41·4	50·0	50·0	47·0	47·1	40·6	·161	·099	·122	·153	·134	·164	44	12	16	28	25	47	...	0	10	*b*	*b*	*o*
11	43·0	51·0	52·8	49·0	49·7	42·2	·193	·169	·172	·109	·168	·185	52	23	24	15	28	51	...	0	10	*b*	*b*	*mm*
12	44·0	47·0	59·1	46·0	49·0	42·5	·186	·093	·103	·096	·195	·141	46	15	60	10	34	32	...	10	10	*m*	*mm*	*mm*
13	43·5	48·8	46·9	45·0	46·1	42·7	·137	·165	·175	·164	·160	·132	31	29	33	35	32	29	...	10	10	*mm*	*mm*	*mm*
14	44·5	46·5	45·8	43·0	44·9	44·3	·226	·277	·288	·256	·262	·261	65	60	84	85	78	81	0·10	10	10	*d* 8—16	*d*	*mm*
15	40·1	47·0	50·0	44·0	45·5	40·2	·223	·214	·213	·220	·225	·233	81	53	37	61	58	88	...	10	10	*o*	*o*	*o*
16	35·0	51·0	52·2	43·5	45·7	34·8	·184	·192	·138	·193	·177	·182	70	29	16	53	44	84	...	0	0	*bb*	*bb*	*bb*
17	37·0	53·5	56·0	46·5	48·6	37·4	·173	·157	·170	·214	·179	·176	61	19	17	51	37	67	...	0	0	*bb*	*bb*	*bb*
18	42·5	57·6	58·1	50·0	52·0	40·0	·182	·221	·266	·202	·218	·200	52	24	12	34	31	65	...	0	3	*bb*	*bb*	*bb* c.s.
19	44·0	60·1	60·1	53·0	54·3	43·4	·170	·220	·151	·266	·202	·174	40	18	10	43	28	43	...	0	4	*bb*	*bb*	*bb* c.s.
20	45·5	56·9	61·1	53·0	54·1	44·5	·203	·192	·175	·232	·201	·204	50	17	11	34	28	51	...	0	0	*bb*	*bb*	*bb*
21	47·5	61·6	62·7	55·6	56·9	46·7	·204	·232	·171	·212	·205	·218	44	19	11	26	25	48	...	0	3	*bb*	*bb*	*bb* K S.
22	54·0	64·1	61·6	53·0	58·1	53·2	·252	·298	·226	·140	·229	·269	36	21	17	16	23	43	...	9	10	*b* K.S.	*b* K.S.	*mm*
23	49·5	56·1	58·0	55·1	54·8	48·3	·115	·119	·123	·160	·129	·117	19	10	9	16	13	23	...	10	10	*b*	*o*	*o*
24	54·5	56·6	58·6	57·1	56·7	54·1	·223	·250	·272	·294	·260	·266	31	31	31	39	33	40	...	10	10	*mm*	*mm*	*mm*
25	53·8	61·6	62·4	55·1	58·2	53·4	·246	·330	·311	·229	·279	·255	39	34	27	28	32	38	...	10	10	*mm*	*mm*	*mm*
26	52·8	57·1	57·1	53·0	55·0	51·4	·300	·232	·215	·209	·239	·236	53	25	22	28	32	39	...	10	10	*mm*	*mm*	*mm*
27	52·5	60·1	62·2	56·9	57·9	52·0	·217	·277	·314	·204	·276	·262	34	26	28	37	31	40	...	10	10	*mm*	*m*	*mm*
28	53·5	58·1	58·1	55·1	56·2	53·1	·271	·255	·197	·252	·244	·283	46	27	17	33	31	48	...	10	10	*m*	*m*	*m*
29	50·0	57·6	61·1	57·7	56·6	49·3	·219	·216	·261	·216	·235	·217	38	23	22	29	28	39	...	10	10	*m*	*m*	*m*
30	53·0	57·0	53·5	49·0	53·1	52·3	·277	·238	·232	·132	·220	·278	47	28	35	19	32	49	...	10	10	*mm*	*mm* dust storm at 12 30h. from N.W	*mm*
31	46·0	51·0	54·0	45·0	49·0	44·7	·124	·101	·218	·074	·129	·134	23	12	9	12	11	24	...	10	10	*b* c K.	*mm*	*mm*
Mean ..	46·3	55·5	56·3	50·3	52·1	45·5	·199	·206	·205	·193	·201	·202	45	25	23	32	31	47	0·10	5·42	7·58	...	...	...

TABLE I. (Continued).—*Observations at Yangi Shahr, Yárkand, June 1875.*

Day of Month.	Barometer reduced to 32°.					Air Temperature.								Temperature of Radiation.				Wind.				
	4 h.	10 h.	16 h.	22 h.	Mean.	4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min.	Range.	Sun Max.	Diff sun and shade.	Wool rad	Diff. shade and rad.	10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	25·892	25·905	25·821	25·914	25·888	54·1	78·2	82·2	68·1	70·7	84·9	52·0	32·9	147·0	62·1	40·8	11·2	W. N. W.	W.	77·9	40·0	117·9
2	26·006	26·026	25·910	26·013	25·989	51·0	73·1	79·7	63·1	67·6	83·4	50·9	32·5	144·0	60·6	36·1	14·8	N. N. E.	N. N. E.	13·6	11·6	25·2
3	25·924	25·924	25·834	25·861	25·886	55·6	73·1	77·7	62·1	67·1	84·4	53·0	31·4	141·0	56·6	45·9	7·1	N. W.	W. N. W.	17·4	14·8	32·2
4	25·812	25·801	25·669	25·733	25·750	56·6	81·2	82·4	72·1	73·1	90·9	55·2	35·7	161·5	60·6	48·0	7·2	S.	N. N. W	22·6	14·1	36·7
5	25·700	25·807	25·729	25·783	25·777	62·1	85·2	90·7	67·1	76·3	93·9	59·7	34·2	156·0	62·1	53·0	6·8	N. N. W.	S.	69·1	17·0	76·1
6	25·801	25·810	25·693	25·705	25·761	55·1	86·2	95·3	66·1	75·7	97·4	53·6	43·8	163·2	65·8	45·6	8·0	N. W.	S. E.	32·7	9·0	41·7
7	25·713	25·727	25·617	25·732	25·697	57·6	88·2	90·7	77·2	78·4	98·6	57·5	41·1	160·0	60·4	45·3	12·2	W. S. W.	N. W.	7·8	37·2	45·0
8	25·750	25·777	25·601	25·730	25·734	60·1	89·2	95·3	75·2	81·4	97·4	64·6	32·8	158·5	61·1	55·9	8·7	N. E.	W. N. W.	65.3	12·7	78·0
9	25·772	25·763	25·681	25·707	25·730	64·6	85·7	89·2	77·2	79·2	96·4	63·2	33·2	156·0	59·6	54·7	8·5	N. N. W.	N. W.	30·6	16·6	47·2
10	25·720	25·701	25·579	25·650	25·663	71·1	89·2	92·3	74·1	81·7	96·4	69·6	26·8	154·5	58·1	64·9	4·7	N. N. W.	S. S. E.	69·6	15·8	85·4
11	25·689	25·651	25·517	25·618	25·626	64·1	88·2	90·0	70·7	79·8	96·5	63·2	33·3	155·5	59·0	52·2	11·0	W. N. W.	N. N. E.	51·9	13·4	65·3
12	25·639	25·639	25·637	25·694	25·652	65·1	89·0	79·2	73·1	76·6	91·4	63·7	27·7	166·0	74·6	55·3	8·4	W. N. W.	W. N. W.	59·2	33·6	92·8
13	25·724	25·718	25·680	25·765	25·722	67·6	81·2	82·4	70·1	75·3	86·2	65·4	20·8	137·5	51·3	61·3	4·1	N. W.	S. E.	121·5	15·5	137·0
14	25·820	25·806	25·675	25·805	25·776	63·6	82·2	85·7	66·1	74·4	90·4	61·1	29·3	155·5	65·1	53·4	7·7	S. E.	S. S. E.	48·2	23·2	71·4
15	25·785	25·752	25·637	25·707	25·721	60·1	82·2	86·2	68·1	74·1	90·6	59·2	31·4	151·8	61·2	53·0	6·3	N. N. W.	S. S. E.	28·9	18·1	47·0
16	25·771	25·771	25·670	25·700	25·720	57·4	77·7	80·2	64·1	69·9	86·4	57·1	29·3	151·0	64·6	53·6	3·5	N. N. E.	W. N. W.	24·0	8·8	32·8
17	25·721	25·704	25·618	25·723	25·692	57·1	85·2	88·2	80·2	77·7	93·9	55·9	38·0	155·5	61·6	45·7	10·2	W. N. W.	N. W.	8·4	9·8	18·2
18	25·784	25·821	25·709	25·855	25·814	70·6	71·0	78·7	66·1	71·7	85·6	69·2	17·4	144·5	58·9	69·3	0·9	W. N. W.	W.	75·8	52·4	128·2
19	25·857	25·852	25·756	25·832	25·824	56·1	83·7	84·2	65·1	72·3	93·4	55·4	38·0	158·5	65·1	45·4	10·0	S.	S. S. E.	20·9	13·3	34·2
20	25·854	25·819	25·736	25·810	25·813	58·6	83·2	91·8	75·2	77·2	95·5	57·3	38·2	154·0	58·5	49·0	8·3	S. S. E.	S. S. E.	20·8	9·4	30·2
21	25·603	25·767	25·602	25·667	25·710	65·1	85·2	93·3	80·2	80·9	95·4	64·4	31·0	152·5	57·1	60·4	4·0	N.	N. W.	68·1	13·4	81·5
22	25·776	25·819	25·716	25·721	25·773	63·1	70·0	81·7	62·1	69·2	84·4	61·8	22·6	144·5	60·1	56·9	4·9	W. N. W.	S. S. E.	195·4	22·9	218·3
23	25·733	25·688	25·512	25·596	25·632	57·1	81·7	86·2	75·7	75·2	93·6	56·4	37·2	150·5	56·9	47·4	9·0	W. N. W.	S. E.	21·6	7·6	29·2
24	25·620	25·641	25·588	25·665	25·629	70·1	81·2	82·7	73·1	76·8	89·4	69·2	20·2	146·5	57·1	65·3	3·9	W. N. W.	N. N. W.	107·4	29·7	137·1
25	25·655	25·669	25·600	25·790	25·679	65·1	84·7	89·2	70·1	77·3	94·5	63·6	30·9	152·5	58·0	59·3	4·3	N. W.	N.	81·3	23·3	101·5
26	25·815	25·709	25·704	25·700	25·769	65·9	86·7	90·4	75·2	79·6	94·6	64·8	29·8	159·5	64·9	61·1	3·7	N. W.	S. E.	114·0	10·8	124·8
27	25·716	25·801	25·750	25·804	25·775	74·1	81·2	84·4	73·9	78·4	88·6	72·1	16·5	124·0	35·4	71·8	0·3	N. W.	N. W.	31·6	15·8	47·4
28	25·776	25·743	25·639	25·682	25·710	69·1	86·2	86·2	73·1	78·7	94·9	68·2	26·7	139·0	44·1	64·7	3·5	W.	W.	22·6	6·4	29·0
29	25·670	25·697	25·510	25·604	25·620	69·4	87·1	89·7	79·2	81·3	94·9	68·6	26·3	144·5	49·6	63·9	4·7	W.	W.	16·8	8·8	25·6
30	25·600	25·509	25·515	25·617	25·583	74·1	81·2	82·5	70·1	76·9	91·2	72·1	19·1	143·5	52·3	69·3	2·8	N. W.	W. N. W.	97·3	16·9	114·2
Mean.	25·769	25·709	25·672	25·713	25·738	63·0	82·0	86·3	71·3	75·8	91·8	61·6	30·2	150·6	58·8	54·9	6·7	...	...	53·7	19·1	72·8

Day of month.	Temperature of evaporation.						Computed Vapour Tension.						Relative Humidity.						Rain.	Clouds.		Beaufort's and cloud initials.		
	4 h.	10 h.	16 h.	22 h.	Mean.	Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From min.	4 h.	10 h.	16 h.	22 h.	Mean.	From min.	Inches.	10 h.	16 h.	Before 10 h.	10 h. to 16 h.	After 16 h.
1	41·3	52·5	53·1	47·0	49·3	40·7	·116	·211	·153	·093	·141	·127	24	12	14	13	17	32	...	1	3	*b* x. s.	*b* x. s.	*b* x. s.
2	41·0	50·0	52·8	47·0	47·7	40·2	·105	·090	·094	·142	·111	·129	25	12	0	25	17	34	...	10	10	*m*	*m*	*m*
3	43·0	52·0	55·0	52·0	50·7	43·1	·137	·149	·143	·274	·156	·160	31	15	21	40	30	45	...	10	10	*m*	*m*	*m*
4	46·3	59·1	57·1	54·0	54·2	46·3	·200	·249	·151	·212	·210	·223	46	24	16	27	28	51	...	10	10	*m*	*m*	*m*
5	48·0	56·8	62·2	53·0	54·9	48·2	·178	·259	·224	·243	·221	·203	32	12	10	37	24	40	...	0	5	*b*	*bb*	*b* x. s.
6	47·0	61·0	62·7	52·3	54·9	46·9	·232	·255	·154	·251	·220	·247	54	22	12	38	32	60	...	0	3	*b*	*b*	*b* x. s.
7	47·5	61·0	63·2	56·1	57·1	47·2	·219	·232	·260	·210	·228	·260	44	10	18	23	26	44	...	1	8	*b*	*b* s	*b* x. s.
8	52·0	62·3	65·2	60·1	53·9	51·8	·229	·215	·272	·316	·273	·229	36	15	17	40	28	30	...	0	5	*b*	*b*	*b* x. s.
9	55·1	63·2	64·2	61·6	61·0	55·0	·325	·317	·310	·358	·327	·310	53	26	23	40	36	50	...	10	10	*m*	*m*	*m*
10	57·1	63·2	67·2	60·1	61·9	56·3	·200	·277	·373	·358	·324	·303	49	20	25	43	32	41	...	10	9	*m*	*m*	c. x s. *lt.* from 17·25 to 17·50. Big drops of rain.
11	55·1	62·2	65·2	59·1	60·2	54·3	·320	·259	·329	·272	·293	·320	55	10	23	30	32	55	0·03	0	9	*bb*	*bb*	c s.
12	53·7	61·2	59·1	57·1	55·3	52·2	·219	·310	·273	·284	·270	·264	41	23	27	35	31	44	...	8	10	*b*	*b* s	*mm*
13	52·0	60·1	62·7	51·0	56·4	51·1	·211	·277	·226	·158	·213	·213	31	26	31	22	27	34	...	10	10	*b* c. s.	*m*	*m*
14	54·0	62·7	63·2	55·1	58·7	53·5	·309	·331	·317	·308	·316	·323	53	32	26	48	40	60	...	2	1	*b* s	*b* s	*b* s
15	54·0	58·6	62·2	54·0	57·2	53·4	·319	·215	·250	·264	·277	·312	67	20	23	33	37	68	...	0	2	*b*	*bb*	*b* x. s.
16	51·0	61·1	61·1	53·9	56·5	50·3	·303	·347	·318	·277	·311	·257	63	37	31	47	41	62	...	0	10	*b*	*b*	*m*
17	51·0	61·1	61·1	57·1	57·6	50·8	·336	·261	·228	·224	·249	·313	60	22	17	20	31	71	...	10	10	*b* c	c	*m*
18	56·6	58·0	58·6	56·1	57·5	55·3	·290	·333	·255	·335	·303	·291	40	45	27	52	41	42	...	10	10	*mm*	*mm*	c
19	51·0	63·2	61·6	53·1	55·5	50·8	·317	·340	·278	·402	·334	·319	71	30	25	65	48	73	...	2	2	*b* c. s.	*b* s	*b* c. s.
20	52·5	63·2	65·2	58·1	59·7	51·3	·320	·316	·312	·289	·317	·310	67	31	21	33	39	66	...	0	1	*bb*	*bb*	*b* c. s.
21	55·1	63·2	65·4	61·1	61·2	54·2	·319	·323	·295	·315	·314	·301	53	27	19	31	32	51	...	0	3	*b*	*b*	*b* c. s.
22	52·5	55·1	59·6	54·9	55·3	52·3	·268	·263	·219	·320	·277	·284	48	3	24	59	42	51	...	10	10	*mm*	*mm*	*b*
23	50·0	61·1	64·2	59·1	58·6	50·2	·251	·310	·314	·312	·312	·294	61	28	28	37	38	65	...	8	9	*b*	c. x. s	c s
24	57·6	61·6	63·2	57·0	60·0	56·6	·323	·312	·351	·289	·319	·316	46	31	32	37	37	44	...	9	10	*b*	c. x. s.	o
25	54·0	62·7	64·7	57·9	59·8	54·0	·292	·303	·315	·345	·314	·208	47	27	24	47	36	53	...	10	8	*b*	*m*	c x. s.
26	55·1	63·2	67·7	61·9	62·5	54·7	·308	·370	·377	·406	·365	·313	49	29	31	46	39	51	...	1	10	*b* c. s.	*b* s	*m*
27	58·6	62·2	65·2	59·1	61·3	58·0	·306	·337	·398	·328	·342	·321	38	32	34	39	36	41	...	10	10	*mm*	*mm*	*mm*
28	65·1	61·2	65·2	61·1	61·4	55·2	·274	·244	·375	·390	·318	·288	30	28	30	49	37	42	...	10	10	*mm*	*mm*	*mm*
29	57·6	64·2	70·2	61·1	63·3	57·4	·328	·333	·507	·330	·375	·314	48	20	37	33	36	50	...	10	10	*mm*	*mm*	*mm*
30	60·1	64·2	65·1	61·1	62·4	58·6	·329	·402	·395	·483	·390	·338	30	38	37	50	43	43	...	10	10	*mm*	*m*	*mm*
Mean ...	52·1	60·7	62·8	56·5	58·0	51·7	·263	·290	·292	·291	·284	·270	47	26	24	39	34	50	0·03	5·73	7·60	...	...	......

TABLE I. (Continued).—*Observations at Yangi Shahr, Yárkand, July 1875.*

Day of month	Barometer reduced to 32°.					Air Temperature.								Temperature of Radiation.				Wind.				
	4 h.	10 h.	16 h.	22 h.	Mean.	4 h.	10 h.	16 h.	22 h.	Mean.	Max.	Min	Range	Sun Max	Diff sun and shade	Wool rad.	Diff. shade and rad.	10 h.	16 h.	10 h. miles.	16 h. miles.	Total miles.
1	25·569	25·554	25·608	25·650	25·570	64·1	86·2	92·3	79·2	80·4	95·1	63·2	31·9	153·5	58·4	58·7	4·5	W. N. W.	N. N. W.	92·5	40·6	133·1
2	25·639	25·653	25·601	25·674	25·642	68·0	89·2	93·3	76·2	81·8	95·4	66·6	28·8	154·0	58·6	62·9	3·7	N. N. W.	N. N. E.	76·5	34·4	110·9
3	25·708	25·759	25·660	25·720	25·712	67·1	90·2	93·3	81·2	82·9	96·4	65·5	30·9	157·5	61·1	55·4	10·1	N. N. W.	N. W.	54·8	20·3	75·1
4	25·751	25·750	25·638	25·680	25·705	70·6	93·3	96·8	73·6	83·6	98·4	69·2	29·2	159·5	61·1	61·0	7·3	N. W.	N. W.	52·0	31·0	83·0
5	25·710	25·722	25·607	25·610	25·660	65·1	89·7	97·5	75·7	82·0	98·9	63·9	35·0	158·0	59·1	56·3	7·1	N. W.	N. W.	29·0	14·8	43·8
6	25·668	25·738	25·667	25·750	25·706	69·6	93·3	96·8	78·7	84·6	99·3	69·0	30·3	156·5	57·2	63·9	5·1	W.	N. N. E.	35·4	14·7	50·1
7	25·759	25·833	25·736	25·788	25·779	70·6	93·3	98·8	79·2	85·5	100·9	69·7	31·2	156·0	55·1	61·9	7·8	N. N. W.	N. N. W.	10·0	7·9	17·9
8	25·775	25·846	25·664	25·678	25·741	72·0	92·3	99·5	77·2	85·3	100·0	71·2	29·7	157·0	56·1	65·8	5·4	N. W.	S. S. E.	22·2	5·7	27·9
9	25·699	25·743	25·616	25·664	25·698	72·1	95·8	99·3	83·2	87·6	101·9	71·2	30·7	162·5	60·0	65·2	6·0	N. N. W.	W. N. W.	22·8	7·7	30·5
10	25·687	25·721	25·602	25·607	25·654	71·1	95·3	99·3	85·2	87·7	101·4	69·2	32·2	161·0	59·6	61·9	7·3	N. E.	W. N. W.	31·9	18·4	50·3
11	25·591	25·606	25·401	25·403	25·538	75·7	96·3	101·3	82·2	88·9	102·9	74·6	28·3	161·5	58·6	68·7	5·9	N.	N.	40·2	8·0	48·2
12	25·444	25·468	25·339	25·371	25·405	74·1	92·3	97·3	86·2	87·5	101·4	73·7	27·7	161·0	58·0	65·6	8·1	N. W.	S. E	30·2	4·5	13·7
13	25·434	25·491	25·383	25·403	25·428	77·2	79·2	84·2	77·2	79·4	90·5	73·8	16·7	143·5	53·0	?	?	N. N. W.	N. W.	32·2	7·1	39·3
14	25·423	25·563	25·605	25·753	25·583	73·1	80·2	79·2	69·1	72·9	88·4	70·7	17·7	135·0	40·6	68·1	2·6	E.	N.	25·5	16·9	42·4
15	25·731	25·741	25·656	25·744	25·718	61·1	74·1	83·7	68·1	71·8	84·9	58·8	26·1	146·5	60·6	57·8	1·0	W.	S. E.	128·8	13·9	142·7
16	25·696	25·739	25·731	25·776	25·735	67·1	65·1	63·1	62·1	64·4	88·9	63·2	25·7	93·5	4·6	61·9	1·3	N. W.	N. W.	15·2	43·4	58·6
17	25·737	25·731	25·668	25·699	25·700	61·1	74·6	83·2	68·6	71·9	85·4	59·7	25·7	153·5	68·1	68·4	1·3	S. S. E.	S.	36·3	11·6	47·9
18	25·698	25·734	25·659	25·708	25·700	60·6	84·2	90·2	76·2	77·8	93·9	59·8	34·1	153·5	59·6	53·0	6·8	S. S. E.	W. N. W.	6·8	6·3	13·1
19	25·711	25·711	25·629	25·651	25·675	65·6	89·2	95·3	80·2	82·6	98·4	64·7	33·7	155·0	56·6	56·9	7·8	W. N. W.	W.	20·0	9·3	29·3
20	25·637	25·637	25·523	25·576	25·593	71·6	93·3	100·2	87·2	88·1	101·6	70·0	31·6	162·5	60·9	63·4	6·6	N. N. W.	N. W.	14·4	6·0	20·4
21	25·635	25·674	25·579	25·629	25·629	77·2	88·2	90·7	78·7	83·7	97·9	76·0	21·9	154·0	56·1	71·8	1·2	N. W.	N. W.	70·7	21·1	91·8
22	25·670	25·663	25·548	25·580	25·616	72·6	86·7	93·3	75·5	82·0	96·4	71·2	25·2	152·5	56·1	69·3	1·9	N. W.	S. S. E.	31·3	17·5	48·8
23	25·601	25·687	25·603	25·641	25·632	69·1	81·2	92·3	70·2	81·2	93·2	69·2	27·0	145·0	49·8	62·7	5·5	N. N. W.	N. W.	20·0	26·3	46·3
24	25·676	25·751	25·698	25·731	25·712	74·1	85·7	85·2	74·1	79·8	89·9	74·7	16·2	147·0	57·1	73·1	0·6	N. N. W.	N.	37·0	23·3	60·3
25	25·712	25·711	25·654	25·634	25·678	70·1	87·7	92·3	75·2	81·3	96·4	69·2	27·2	152·0	55·6	66·7	2·5	N. N. W.	N.	16·4	13·3	29·7
26	25·647	25·668	25·548	25·581	25·611	66·1	92·3	98·3	80·2	84·2	101·2	65·2	36·0	159·0	57·8	57·4	7·8	N.	N. W.	8·0	8·4	16·4
27	25·600	25·613	25·546	25·594	25·593	75·2	84·7	98·3	80·7	84·7	99·9	72·5	27·4	157·0	57·1	68·8	3·7	N. N. W.	N. N. W.	36·2	10·8	47·0
28	25·660	25·711	25·582	25·595	25·637	73·1	92·3	98·1	76·2	84·9	101·4	71·2	30·2	161·0	59·6	62·9	8·3	N. N. W.	N. N. W.	34·3	17·0	51·3
29	25·575	25·584	...	...	...	...	...	...	...	...	...	68·2	...	...	...	59·4	8·8	N. N. W.	...	...	...	...
30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mean.	25·653	25·687	25·598	25·641	25·615	69·8	87·5	92·6	77·0	81·7	96·5	68·4	28·1	152·4	55·8	63·0	5·2	...	...	37·1	16·4	53·5

Day of month.	Temperature of evaporation.						Computed Vapour Tension.						Relative Humidity.						Rain.	Clouds.		Beaufort's and cloud initials.		
	4 h.	10 h.	16 h.	22 h.	Mean.	Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	4 h.	10 h.	16 h.	22 h.	Mean.	From Min.	Inches.	10 h.	16 h.	Before 10 h.	10 h. to 16 h.	After 16 h.
1	[illegible]	62·7	63·1	[illegible]	62·1	57·5	·414	[illegible]	[illegible]	·300	·313	·409	69	24	20	56	37	71	...	1	5	b c. s.	b c s.	b x s.
2	[illegible]	62·3	61·2	[illegible]	60·2	54·1	·312	·274	·244	·237	·275	·277	44	27	17	27	29	43	...	0	3	b	b	b k. s.
3	[illegible]	62·2	60·2	[illegible]	[illegible]	52·2	[illegible]	[illegible]	·331	·402	·373	·341	45	29	23	34	33	59	...	0	4	b c s	b	b c k. s.
4	[illegible]	72·2	74·2	61·2	67·2	55·2	·315	·241	·377	·373	[illegible]	·377	44	25	24	33	44	30	...	0	1	b c. k. s	b	b k. s.
5	[illegible]	77·2	74·2	[illegible]	[illegible]	53·2	·384	·241	·372	·494	[illegible]	[illegible]	54	42	33	64	47	18	...	0	0	b k. s.	b	b
6	61·1	72·1	77·1	[illegible]	[illegible]	57·7	·442	·234	[illegible]	[illegible]	[illegible]	·344	63	43	40	60	51	47	...	0	0	b c. k. s.	b	b
7	[illegible]	72·2	78·1	62·2	[illegible]	[illegible]	[illegible]	·379	[illegible]	·454	·314	·324	56	37	34	40	43	49	...	10	10	b	m	m
8	[illegible]	71·2	77·1	61·2	[illegible]	[illegible]	·474	[illegible]	·271	·417	·327	·374	63	32	35	47	47	49	...	10	10	m	m	m
9	[illegible]	74·2	[illegible]	[illegible]	62·7	[illegible]	[illegible]	·259	·213	·443	·331	·314	44	35	24	39	40	44	...	10	10	m	m	m
10	[illegible]	72·2	73·1	[illegible]	[illegible]	54·2	·292	·317	·429	[illegible]	·377	·394	52	31	31	41	39	42	...	10	10	m	m	m
11	62·1	72·2	73·1	62·2	[illegible]	54·2	·377	·344	·375	·311	·423	·379	43	32	29	30	34	31	...	10	10	b	m	m
12	[illegible]	71·2	77·1	[illegible]	[illegible]	[illegible]	[illegible]	·241	[illegible]	·623	·579	·397	54	74	40	60	40	37	...	10	2	b k. s.	m	b k. s.
13	[illegible]	60·2	72·1	[illegible]	[illegible]	62·2	·479	·452	·703	·312	·501	·425	72	49	63	55	65	51	...	10	10	m m	m m	m m
14	67·2	[illegible]	62·2	57·6	62·1	61·7	·471	·445	·391	·443	·479	·419	57	43	38	91	57	55	...	10	10	m m	m m	m m dr 20 to 22.
15	[illegible]	65·7	63·7	61·1	61·9	55·3	·419	·319	·348	·456	·475	·431	78	63	32	67	60	57	0·20	0	1	b k. s.	b s	b c. s.
16	60·1	61·1	62·1	[illegible]	67·3	57·7	·439	·391	·481	·4·5	·477	·473	64	60	44	62	50	81	0·04	10	10	dr 7 to 7·30	d	m m dr 19 to 19.
17	[illegible]	64·2	67·7	62·7	63·1	54·2	·449	[illegible]	·453	·467	·452	·497	63	59	44	71	64	91	0·02	6	2	b k. s.	b c. k. s.	b c k. s.
18	57·4	67·2	[illegible]	64·2	[illegible]	57·2	·431	[illegible]	·312	·438	·467	·429	83	40	24	51	50	64	...	1	2	b b c. s.	b b s	b c s. c
19	60·1	70·2	72·2	66·2	67·2	[illegible]	·455	·319	·317	·474	·491	·441	74	34	31	47	49	72	...	10	0	m	m	b k. s.
20	63·2	73·2	71·2	[illegible]	60·2	62·2	·479	·379	[illegible]	·431	·497	·453	63	37	24	34	40	64	...	10	0	b c. s.	m	b m k. s.
21	65·2	67·2	71·2	67·2	[illegible]	65·0	·473	[illegible]	·333	·329	·504	·423	52	37	37	55	45	44	...	0	10	c o	b k. s.	o
22	63·7	72·2	76·2	67·2	67·4	62·4	·472	·616	·619	·601	·546	·462	61	40	40	73	54	60	...	10	10	m m	o	m o
23	[illegible]	70·2	71·2	66·2	65·7	61·2	·529	·371	·420	·449	·557	·460	76	40	42	40	54	67	...	10	10	b o s.	m	m
24	61·7	67·0	[illegible]	65·2	[illegible]	61·6	·457	·401	·448	·314	·405	·409	59	41	41	61	50	49	...	10	10	m	m	m dr 21 to 21·15.
25	64·1	71·2	67·2	64·2	63·2	63·2	·527	·377	·412	·604	·535	·574	72	43	29	70	54	72	0·01	10	9	m	o	c c. k. s.
26	53·6	72·2	71·7	67·7	67·4	54·6	·425	·222	·451	·517	·464	·417	63	37	23	51	45	67	...	10	0	b c. s.	m	b o
27	61·6	63·2	72·2	63·7	64·9	53·7	[illegible]	·404	·453	·443	·431	·307	45	42	27	41	40	45	...	10	10	c	c o	c o
28	56·1	70·2	71·7	62·2	65·3	55·3	·310	·478	[illegible]	[illegible]	·439	·254	33	32	32	44	37	23	...	0	1	o	b	b c s.
29	...	...	...	...	...	55·0	...	...	...	...	...	[illegible]	...	...	...	...	...	12	...	...	...	b	b	...
30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mean ...	60·5	66·6	71·5	61·2	65·6	59·1	·416	·318	·333	·464	·443	·379	59	41	30	53	47	56	0·27	6·60	5·93	...	...	...

TABLE II.

Hourly observations at Kashghár and Yárkand.

Hours.	7th November 1874—(*Kashghár.*)								14th November 1874—(*Kashghár.*)							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·984	34·5	28·4	·098	18·0	49	...	...	26·257	27·0	24·7	·112	21·0	76	...	...
1 ...	·996	31·0	28·2	·128	24·0	73	...	...	·228	27·0	23·9	·100	18·4	68	...	...
2 ...	·992	32·8	27·9	·106	19·6	56	...	...	·223	27·0	23·9	·100	18·4	68	...	...
3 ...	·992	32·0	31·1	·167	30·2	92	...	...	·241	25·0	22·9	·104	19·2	77	...	...
4 ...	26·013	30·0	28·4	·142	26·4	85	...	...	·233	25·0	22·9	·101	19·2	77	...	...
5 ...	·025	29·0	25·9	·111	20·8	69	...	...	·231	25·0	22·7	·101	18·6	75	...	...
6 ...	·037	29·1	24·9	·095	17·2	60	...	...	·230	24·0	22·4	·106	19·6	82	...	...
7 ...	·027	27·0	24·1	·102	18·8	70	...	...	·244	25·0	22·9	·104	19·2	77	...	...
8 ...	·080	28·0	25·9	·121	22·6	79	...	...	·245	29·9	26·7	·115	21·6	70	...	...
9 ...	·094	34·0	29·9	·128	24·0	65	...	...	·242	35·2	30·9	·133	24·8	64	...	...
10 ...	·101	40·5	32·7	·101	18·6	40	...	...	·245	37·2	31·9	·123	23·0	55	...	...
11 ...	·097	44·1	34·9	·103	19·0	36	...	...	·232	40·0	34·4	·138	25·8	55	...	...
12 ...	·094	47·4	37·7	·120	22·4	37	...	...	·208	45·1	36·9	·130	24·4	43	...	...
13 ...	·060	50·6	38·4	·099	18·2	27	...	...	·187	47·1	38·4	·138	25·8	42	...	...
14 ...	·048	51·9	39·4	·105	19·4	27	...	...	·175	48·1	38·4	·127	23·8	37	...	...
15 ...	·046	52·1	40·4	·123	23·0	31	...	...	·172	49·1	38·7	·122	22·8	35	...	...
16 ...	·046	48·1	37·4	·107	19·8	31	...	...	·163	46·4	36·9	·116	21·8	37	...	...
17 ...	·046	41·9	34·8	·124	23·2	47	...	...	·181	40 0	33·4	·120	22·4	48	...	...
18 ...	·079	37·5	31·9	·120	22·4	53	...	...	·186	37·0	31·7	·123	23·0	55	...	...
19 ...	·085	35·8	29·9	·110	20·6	52	...	...	·186	34·0	30·4	·137	25·6	69	...	...
20 ...	·103	34·0	28·4	·103	19·0	52	...	...	·184	32·0	29·1	·133	24·8	73	...	...
21 ...	·117	34·0	28·2	·099	18·2	50	...	...	·179	30·5	28·4	·137	25·6	80	...	...
22 ...	·135	32·2	28·3	·119	22·4	64	...	...	·187	30·0	26·9	·117	22·0	70	...	...
23 ...	·145	32·8	29·7	·136	25·4	73	...	...	·178	27·0	25·1	·118	22·2	80	...	...
24 ...	·158	30·0	27·9	·133	24·8	80	...	...	·180	27·0	24·9	·115	21·6	78	...	...

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st November 1874—(*Kashghár.*)								28th November 1874—(*Kashghár.*)							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind.		Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind.	
							Direction.	Velocity.							Direction.	Velocity.
24 ...	...	...	...	...	...	...	...	...	26·140	15·5	14·4	·074	11·6	84	...	...
1 ...	...	...	...	...	...	...	...	...	·124	14·0	13·4	·075	11·8	92	...	...
2 ...	...	...	...	...	...	...	...	...	·116	13·5	12·9	·073	11·2	92	...	...
3 ...	...	...	...	...	...	...	...	...	·111	12·0	10·9	·062	7·6	83	...	...
4 ...	...	...	...	...	...	...	...	...	·101	12·0	10·9	·062	7·6	83	...	...
5 ...	...	...	...	...	...	...	...	...	·092	11·5	9·9	·054	4·6	74	...	...
6 ...	...	...	...	...	...	...	...	...	·096	11·0	9·9	·059	6·4	83	...	...
7 ...	...	...	...	...	...	...	...	...	·097	12·0	11·4	·069	10·0	91	...	...
8 ...	...	...	...	...	...	...	...	...	·110	14·0	13·4	·075	11·8	92	...	...
9 ...	...	...	...	...	...	...	...	...	·108	17·0	15·9	·080	13·2	85	...	...
10 ...	...	...	...	...	...	...	...	...	·116	20·0	18·4	·086	15·0	80	...	...
11 ...	...	...	...	...	...	...	...	...	·097	24·0	20·9	·084	14·4	65	...	...
12 ...	...	...	...	...	...	...	...	...	·074	26·8	22·9	·086	15·0	59	...	...
13 ...	...	...	...	...	...	...	...	...	·044	27·5	22·9	·079	13·0	53	...	...
14 ...	...	...	...	...	...	...	...	...	·024	28·0	22·9	·074	11·6	48	...	...
15 ...	...	...	...	...	...	...	...	...	·027	27·3	22·2	·071	10·6	47	...	...
16 ...	...	...	...	...	...	...	...	...	·027	27·0	21·9	·069	10·0	47	...	...
17 ...	...	...	...	...	...	...	...	...	·021	25·0	21·1	·081	13·6	57	...	...
18 ...	...	...	...	...	...	...	...	...	·024	24·0	21·8	·096	17·4	76	...	...
19 ...	...	...	...	...	...	...	...	...	·016	23·0	20·9	·084	14·4	65	...	...
20 ...	...	...	...	...	...	...	...	...	·024	22·0	20·4	·096	17·4	81	...	...
21 ...	...	...	...	...	...	...	...	...	·053	20·0	18·9	·093	16·6	86	...	...
22 ...	...	...	...	...	...	...	...	...	·041	18·0	16·9	·084	14·4	86	...	...
23 ...	...	...	...	...	...	...	...	...	·041	17·5	16·4	·082	13·8	85	...	...
24 ...	...	...	...	...	...	...	...	...	·030	16·8	15·4	·076	12·2	81	...	...

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	7th December 1874—(Kashghár.)								14th December 1874—(Kashghár).							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	26·039	26·0	24·9	·125	23·4	89	...	...	25·862	20·0	18·9	·093	16·7	86	...	...
1 ...	·024	25·2	24·4	·125	23·4	92	...	...	·850	21·0	19·9	·098	17·9	87	...	...
2 ...	·012	23·2	22·7	·118	22·2	94	...	...	·852	21·9	20·7	·101	18·6	87	...	...
3 ...	·016	22·0	20·9	·103	19·0	87	...	...	·863	20·0	18·9	·093	16·7	86	...	...
4 ...	·003	21·0	19·9	·098	17·8	87	...	...	·843	19·8	18·4	·088	15·5	83	...	...
5 ...	·005	20·0	18·4	·086	15·0	80	...	...	·846	20·0	18·7	·090	16·0	81	...	...
6 ...	·023	19·0	18·4	·096	17·4	93	...	...	·852	17·0	15·9	·080	13·3	85	...	...
7 ...	·025	20·0	18·7	·090	16·0	84	...	...	·854	17·2	16·2	·082	13·8	85	...	...
8 ...	·051	20·0	18·9	·093	16·6	86	...	...	·873	17·8	16·7	·083	14·1	86	S. W.	...
9 ...	·040	22·0	21·3	·109	20·2	93	...	...	·881	19·5	18·5	·092	16·5	86	S. W.	...
10 ...	·058	27·0	25·7	·128	24·0	87	...	...	·904	28·0	25·4	·113	21·2	73	W. S. W.	...
11 ...	·042	31·0	28·4	·132	24·6	75	...	...	·886	36·8	31·7	·125	23·4	57	West	...
12 ...	25·996	35·0	30·9	·135	25·2	66	...	...	·883	37·5	32·1	·124	23·3	54	West	...
13 ...	·997	37·5	31·9	·120	22 5	53	...	...	·864	41·0	34·7	·133	24·9	52	North	...
14 ...	·984	39·8	34·4	·141	26·2	56	...	...	·844	43·1	35·9	·133	24·9	48	E. N. E.	...
15 ...	·984	39·8	34·7	·146	27·0	60	...	...	·849	42·1	35·9	·144	26·7	51	North	...
16 ...	·985	38·0	33·2	·138	25·7	60	...	...	·854	41·0	34·3	·125	23·4	49	North	...
17 ...	·990	35·0	30·7	·132	24·7	65	...	...	·866	35·5	30·4	·122	22·9	58	N. N. W.	...
18 ...	26·016	28·0	24·9	·105	19·4	69	...	...	·871	31·8	27·7	·113	21·1	63	...	...
19 ...	·039	27·0	25·1	·118	22·2	80	...	...	·887	29·0	25·9	·111	20·8	69	...	...
20 ...	·049	26·5	24·9	·120	22·5	83	...	...	·886	29·0	25·9	·111	20·8	69	...	...
21 ...	·071	26·0	24·1	·112	20 9	80	...	...	·879	28·2	25·5	·113	21·1	73	...	...
22 ...	·091	23·3	22·4	·113	21·1	91	...	...	·882	26·0	24·4	·117	22·0	83	...	...
23 ...	·092	23·2	22·2	·110	20·5	88	...	...	·871	24·0	22·7	·110	20·4	86	...	...
24 ...	·087	21·8	20·7	·102	18·8	87	...	...	·867	22·6	21·6	·107	19·8	87	...	...

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st December 1874—(*Kashghár.*)								28th December 1874—(*Kashghár.*)							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·887	22·0	18·9	·074	11·5	63	...	...	25·907	19·0	17·4	·082	13·8	79	...	...
1 ...	·887	20·5	18·7	·085	14·6	77	...	...	·889	17·5	15·9	·076	12·2	79	...	...
2 ...	·883	19·3	16·9	·072	11·0	69	...	...	·880	15·5	14·4	·074	11·6	84	...	...
3 ...	·886	17·8	15·9	·073	11·2	76	...	...	·880	15·0	13·9	·072	11·0	84	...	...
4 ...	·878	17·5	15·7	·073	11·2	76	...	...	·864	17·0	13·9	·053	4·2	56	...	...
5 ...	·871	16·5	14·9	·072	11·0	78	...	...	·864	15·0	12·9	·059	6·6	69	...	...
6 ...	·866	15·4	13·8	·068	9·7	77	...	...	·869	15·0	12·9	·059	6·6	69	...	...
7 ...	·871	13·5	11·4	·054	4·6	67	...	...	·875	15·5	13·9	·068	9·6	77	...	...
8 ...	·883	19·0	16·9	·075	11·8	73	West	...	·875	18·0	15·9	·071	10·6	73	N. N. W.	...
9 ...	·887	28·0	24·5	·099	18·2	63	West	...	·893	19·0	17·9	·089	15·8	86	N. N. W.	...
10 ...	·898	34·5	29·2	·111	20·7	55	West	...	·894	21·0	19·9	·098	17·8	87	North	...
11 ...	·871	39·9	31·9	·093	16·7	37	West	...	·881	24·0	21·9	·098	17·8	76	N. E.	...
12 ...	·840	44·9	35·4	·104	19·2	35	N. W.	...	·857	26·5	23·8	·102	18·8	73	E. N. E.	...
13 ...	·814	48·3	37·1	·099	18·2	29	North	...	·835	28·8	21·9	·098	17·8	61	E. N. E	...
14 ...	·798	49·1	37·7	·102	18·8	29	N. N. W.	...	·818	29·1	24·9	·095	17·2	60	N. E.	...
15 ...	·799	48·1	37·7	·113	21·2	31	N. N. W.	...	·814	29·8	25·9	·104	19·2	62	N. E.	...
16 ...	·806	42·2	34·9	·121	23·2	47	North	...	·820	28·0	24·9	·105	19·3	69	N. E.	...
17 ...	·806	36·0	29·9	·108	20·1	51	North	...	·830	28·0	24·9	·105	19·3	69	N. E.	...
18 ...	·812	31·0	28·9	·111	20·7	57	...	...	·826	26·0	22·9	·094	17·0	67	...	...
19 ...	·813	29·0	24·9	·096	17·4	60	...	...	·828	25·0	21·9	·089	15·8	66	...	...
20 ...	·834	28·7	21·6	·094	17·0	60	...	...	·837	23·0	20·9	·093	16·7	76	...	...
21 ...	·829	29·2	24·4	·086	17·4	52	...	...	·853	21·0	18·9	·083	14·1	73	...	...
22 ...	·834	27·8	24·1	·095	17·2	63	...	...	·854	18·0	15·9	·071	10·6	73	...	...
23 ...	·816	25·4	22·7	·097	17·7	72	...	...	·816	18·0	15·9	·071	10·6	73	...	...
24 ...	·838	24·0	21·9	·095	17·9	76	...	...	·811	18·0	16·9	·081	14·4	86	...	...

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	7th January 1875—(*Yarkand.*)								14th January 1875—(*Yarkand.*)							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·820	23·0	20·9	·093	16·7	76	...	...	26·137	14·5	13·4	·070	10·2	84	...	...
1 ...	·816	21·0	19·9	·098	17·9	87	...	...	·131	14·0	12·9	·068	9·6	84	...	...
2 ...	·787	20·5	18·9	·088	15·5	80	...	...	·124	14·0	12·9	·068	9·6	84	...	...
3 ...	·785	20·0	17·9	·079	13·0	73	...	...	·123	13·0	11·9	·065	8·6	83	...	...
4 ...	·818	19·2	16·9	·076	12·3	70	...	...	·109	13·0	10·9	·052	3·6	67	E. S. E.	...
5 ...	·818	19·0	16·9	·075	11·8	73	...	...	·101	12·0	10·9	·062	7·6	83	E. S. E.	0·2
6 ...	·816	19·2	16·9	·076	12·3	70	...	...	·102	12·0	9·9	·049	2·4	66	E. S. E.	0·0
7 ...	·816	18·8	16·8	·076	12·3	73	...	...	·102	12·0	9·9	·049	2·4	66	E. S. E.	0·3
8 ...	·835	18·0	16·4	·078	12·7	79	E.	...	·106	12·0	9·9	·049	2·4	66	S. S. E.	1·5
9 ...	·842	20·0	17·9	·079	13·0	73	E. S. E.	...	·089	12·0	10·9	·062	7·6	83	W. N. W.	1·3
10 ...	·834	22·8	19·7	·078	12·7	64	E. S. E.	...	·092	14·0	12·9	·068	9·6	84	W. N. W.	1·2
11 ...	·816	29·0	24·4	·088	15·5	55	E. S. E.	...	·084	17·5	15·4	·069	10·0	72	W.	6·5
12 ...	·781	29·5	25·4	·099	18·3	60	E.	...	·046	23·0	19·9	·079	13·0	64	N. W.	3·0
13 ...	·779	29·0	23·4	·072	11·0	45	E.	...	·021	25·5	22·4	·092	16·4	66	N.	1·8
14 ...	·758	32·0	27·9	·114	2.4	63	E. N. E.	...	·004	26·5	22·9	·089	15·6	62	N.	5·2
15 ...	·754	31·0	27·9	·123	23·1	71	E. N. E.	...	25·995	26·0	21·9	·079	13·0	56	N.	9·3
16 ...	·746	31·0	24·9	·076	12·3	44	E. N. E.	...	·991	26·0	21·9	·079	13·0	56	N.	6·5
17 ...	·722	28·0	22·9	·074	11·6	48	E. N. E.	...	·992	22·0	19·4	·081	13·6	68	N.	2·4
18 ...	·722	25·0	20·9	·074	11·6	55	E. N. E.	...	·982	21·0	18·9	·083	14·2	73	...	1·6
19 ...	·713	23·8	19·7	·068	9·7	53	...	...	·997	19·0	17·4	·082	13·8	79	...	...
20 ...	·728	22·5	18·9	·069	10·0	57	...	...	·984	19.0	16·9	·075	11·8	73	...	...
21 ...	·720	22·0	18·9	·074	11·6	63	...	...	·991	17·0	15·4	·074	11·6	78	...	...
22 ...	·721	21·5	17·9	·064	8·3	56	...	...	·978	17·0	14·9	·067	9·4	71	...	...
23 ...	·732	19·0	15·9	·061	7·2	59	...	...	·963	15·0	12·9	·059	6·4	69	...	...
24 ...	·733	19·0	16·9	·075	11·8	73	...	...	·950	14·5	12·9	·064	8·2	77	...	...

TABLE II (continued.)—*Hourly observations at Kashghár.*

Hours.	21st January 1875—(Yarkand.)								28th January 1875—(Yarkand.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind.		Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind.	
							Direction.	Velocity.							Direction.	Velocity.
21 ...	26·208	18·0	14 9	·057	5·8	58	S. E.	...	26·400	14·5	11·9	·050	2·8	60	E. N. E.	...
1 ...	·203	17·5	14·4	·055	5·0	57	S. E.	0 8	·405	14·0	11·9	·055	5·0	68	S.	0·1
2 ...	·205	17·5	14·4	·055	5·0	57	S. E.	0·8	·399	14·0	11·9	·055	5·0	68	W.	0·3
3 ...	·210	17·5	11·4	·055	5·0	57	S. E.	0·2	·387	15·0	11·9	·045	0·4	52	W.	5.4
4 ...	·211	18·2	14·9	·055	5·0	56	S. E.	0·4	·381	14·0	11·4	·049	2·4	59	S. W.	0·5
5 ...	·205	16·0	13·4	056	5·2	62	S. S. W.	0·1	·378	13·5	11·1	·049	2·4	62	S. S. W.	0·5
6 ...	·195	13·5	12·9	·047	1·4	59	N. N. W.	0·4	·396	13·2	10·9	·050	2·8	61	S. S. E.	0·2
7 ...	·201	11·5	8·9	·041	?	56	N. N. E.	0·2	·392	13·0	10·9	·052	3·8	67	N. E.	0·9
8 ...	·204	9·0	7·8	·052	3·6	82	E. S. E.	0·2	·382	13·9	11·9	·056	5·4	68	W.	2·8
9 ...	·207	13·2	10·1	·041	0·0	55	S. W.	0·5	·366	15·0	12·9	·059	6·6	69	E. S. E.	2·7
10 ...	·213	20·5	17·1	·063	8·0	57	S. W.	5·6	·396	19·0	16·4	·068	9·6	65	W.	3·8
11 ...	·204	26·0	21·9	·079	13·0	56	S. E.	0 9	·378	24·0	19·9	·069	10·0	53	S. S. E.	3·5
12 ...	·175	28·5	24·4	·093	16·6	59	S. E.	1·5	·319	27·0	21·9	·069	10·0	47	E. S. E.	5·2
13 ...	·140	29·0	23·9	·080	13·2	50	N. N. E.	0.5	·317	28·0	22·9	·074	11·6	48	S.	2·9
14 ...	·135	29·0	23·9	·080	13·2	50	E. N. E.	0·4	·303	29 0	22·9	·061	8·2	40	E. N. E.	2·5
15 ...	·125	29·5	24·9	·091	16·2	56	E. S. E.	0·3	·293	28·0	23·9	·090	16·0	59	N.	1·8
16 ...	·116	28·5	22·9	·069	10·0	44	E.	0·5	·283	29 0	24·9	·096	17·4	60	E. S. E.	2·5
17 ...	·112	26·0	21·4	·072	11·0	50	E. N. E.	0·3	·279	25·0	20·9	·074	11·6	55	E. S. E.	0·3
18 ...	·076	22·0	19·9	·058	15·4	75	N. E.	0·2	·275	22·5	19·4	077	12·4	63	N. E.	2.4
19 ...	·102	21·0	18·9	·083	14·2	73	E.	3·5	·280	20·5	18·9	·088	15·4	80	E.	0·4
20 ...	·100	20·0	17·8	·078	12·8	73	E.	3·5	·275	19·0	14·9	·047	1·4	46	E.	0·1
21 ...	·101	19·0	16·9	·061	7·2	59	N. E.	3·1	·277	17·5	13·9	·048	2·0	50	E. S. E.	0·1
22 ...	·132	18 0	14·9	·057	5·8	58	N. E.	3·2	·271	17·0	13·9	·053	4·2	56	E. S. E.	0·1
23 ...	·125	18·5	14·9	·052	3·6	52	E.	0·9	·264	16·0	12·9	·049	2·4	51	S.	0·5
24 ...	·115	18·5	14·9	·052	3 6	52	E.	0·3	·241	15·0	11·9	·045	0·4	52	S.	0·4

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	7th February 1875.								14th February 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Due point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Due point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·930	79·0	15·9	·061	7·3	59	S.	...	26·182	19·2	14·9	·015	0·5	44	W.	...
1 ...	·917	17·5	14·9	·062	7·5	64	W.	1·2	·167	18·0	13·9	·043	?	44	W.	0 6
2 ...	·924	16·0	13·9	·063	7·9	70	S. W.	0·8	·156	17·0	13·4	·046	0·9	49	W.	0·2
3 ...	·906	14·0	12·9	·055	4·9	68	S. S. W.	0·6	·140	16·0	12·9	·049	2·3	54	W.	0 8
4 ...	·902	14·0	12·9	·055	4·9	68	S.	0·1	·126	15·8	12·4	·044	0·0	49	N. N. W.	0·2
5 ...	·902	14·0	12·9	·055	4·9	68	S.	0·2	·119	15·0	11·9	·045	0·5	52	N. W.	0·7
6 ...	·911	13·0	10·4	·046	0·9	58	S. S. W.	0·6	·111	15·2	12·4	·050	2·8	57	N. W.	2 4
7 ...	·924	11·3	8·9	·043	?	60	S. E.	0·7	·107	15·5	12·8	·053	4·1	61	N. W.	2·0
8 ...	·930	20·0	14·9	·037	?	34	W. N. W.	0·1	·114	19·0	14·9	·047	1·5	46	W. N. W.	3·1
9 ...	·939	25·0	20·4	·067	9·3	49	W. N. W.	1·5	·127	25.0	19·9	·059	6·5	44	N. W.	2·1
10 ...	·945	32 5	27·9	·109	20·3	59	W.	1·8	·110	27·0	21·9	·069	9·9	47	W. N. W.	2·7
11 ...	·934	37·0	31·9	·125	23·4	57	W.	1·4	·107	30·5	24·9	·081	13·6	47	W.	1·9
12 ...	·912	41·5	32·9	·093	16·7	36	N. N. W.	1·0	·079	36·3	30·9	·122	22·5	57	N. N. W	1·6
13 ...	·884	42·1	33·9	·106	19·6	40	E. S. E.	1·8	·016	38·3	29·9	·085	14·7	36	N.	2·4
14 ...	·873	44·1	34·4	·094	17·0	33	E. N. E.	2·2	·019	39·0	32·9	·122	22·5	51	N. E.	2·2
15 ...	·869	46·1	34·9	·081	13·6	26	S. E.	2·4	·001	38·0	31·9	·114	21·4	50	E. N. E.	2·5
16 ...	·858	43·1	33·9	·095	17·2	35	E. S. E.	3·6	25·993	37·0	27·9	·061	8·3	29	N.	1·4
17 ...	·862	41·0	29·9	·058	6·2	24	E. S. E.	1·1	·986	35·0	27·4	·076	12·1	37	S. E.	1·8
18 ...	·863	36·0	27·9	·074	11·5	35	S. E.	1·5	26·003	32·0	26·9	·098	17·9	54	S. E.	2·3
19 ...	·885	32·0	25·9	·082	13·9	45	N. N. E.	0·6	·009	29·0	23·9	·080	13·3	50	N.	0·9
20 ...	·884	30·0	23·9	·070	10·3	42	N. N. E.	1·2	·011	26·0	21·4	·072	10·9	50	E. S. E.	0·7
21 ...	·903	28·0	23·9	·090	16·0	59	N. E.	0·8	·017	24·0	20·9	·084	14·4	65	E. S. E.	0·3
22 ...	·916	27·0	21·9	·069	10·0	47	N. E.	0 6	25·991	23·0	18·9	·064	8·3	52	...	0·0
23 ...	·918	22·0	17·9	·059	6·5	50	W.	1·4	·987	25·0	20·2	·063	7·9	46	E. S. E.	0·6
24 ...	·953	21·0	16·9	·055	4 9	49	W.	0 6	·968	25·0	19·9	·059	6·5	44	E. S. E.	0·3

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st February 1875.						Wind.		28th February 1875.						Wind.	
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Direction.	Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Direction.	Velocity.
21 ...	25·911	26·5	23·9	·101	19·2	73	S. W.	...	25·866	41·0	31·9	·080	13·3	32	W· S· W.	...
1 ...	·930	25·5	22·9	·099	18·2	72	S. S. W.	0·2	·874	43·1	32·9	·077	12·4	28	W· S· W·	2·3
2 ...	·929	23·5	20·9	·088	15·5	70	S. S. W.	0·1	·881	40·0	31·9	·091	16·2	37	W S· W·	2·7
3 ...	·928	22·8	19·9	·080	13·3	66	S.	0·6	·901	39·0	30·9	·095	17·2	40	W·	3·1
4 ...	·925	21·0	17·9	·069	9·9	61	W. S. W.	1·1	·920	36·0	29·9	·108	20·1	51	N· N· W·	1·7
5 ...	·912	19·0	15·9	·061	7·3	59	W.	0·5	·941	35·0	28·9	·101	18·6	50	W· N· W·	2·7
6 ...	·918	19·0	15·9	·061	7·3	59	W N. W.	0·3	26·011	31·0	25·9	·092	16·5	53	W·	3·1
7 ...	·972	21·0	18·9	·083	14·1	73	W.	1·9	·038	31·7	26·4	·093	16·7	51	W·	2·9
8 ...	·982	26·0	22·9	·094	17·0	67	W.	5·4	·074	36·0	29·8	·106	19·7	51	W· N· W·	2·8
9 ...	·991	31·5	27·9	·119	22·3	67	W.	3·4	·106	40·5	31·9	·086	15·0	34	W· N· W·	4·0
10 ...	·993	36·5	31·9	·131	21·5	60	W. N. W.	2·9	·123	47·1	35·9	·089	15·7	28	E·	4·0
11 ...	·981	42·1	34·7	·121	22·7	46	N. W.	0·7	·144	52·1	38·9	·092	16·5	24	N· N· E·	3·0
12 ...	·969	45·1	34·9	·091	16·2	31	N. N. E.	1·2	·139	51·1	39·9	·089	15·7	21	E·	2·8
13 ...	·947	46·1	35·4	·090	16·0	29	E. N. E.	2·5	·137	52·1	40·9	·133	24·8	34	N· E·	2·8
14 ...	·919	48·6	35·9	·072	10·9	21	N. E.	2·9	·138	56.1	42·0	·100	20·3	24	N·	3·0
15 ...	·895	47·1	34·9	·070	10·3	22	N. E.	6·4	·142	56·1	40·9	·088	15·5	20	N· E·	3·0
16 ...	·893	46·1	34·4	·071	10·7	23	E. N. E.	4·2	·156	54·1	39·4	·080	13·3	19	N· E·	3·6
17 ...	·880	43·6	33·4	·081	13·6	28	E. N. E.	1·0	·165	50·1	37·0	·094	17·0	26	E· N· E·	2·9
18 ...	·892	39·0	29·9	·078	12·7	33	S. E.	1·1	·200	42·1	34·9	·125	23·4	47	E· N· E·	1·9
19 ...	·913	38·0	29·4	·080	13·3	34	S.	1·6	·219	41·0	32·4	·090	16·0	35	N· N· E·	2·4
20 ...	·914	37·0	28·9	·081	13·6	37	N.	1·8	·243	38·0	31·9	·114	21·4	50	N·	2·6
21 ...	·926	36·0	28·4	·083	14·1	39	N.	1·6	·267	37·8	29·9	·090	16·0	39	N· N· E·	4·1
22 ...	·920	32·0	24·9	·066	9·0	36	N.	1·1	·295	36·5	28·9	·086	15·0	40	N· E·	1·4
23 ...	·910	32·0	24·9	·066	9·0	36	N.	0·5	·299	35·5	28·4	·088	15·5	42	N· N· E·	3·0
24 ...	·910	31·5	23·9	·055	4·0	31	N. E.	0·5	·311	35·0	27·9	·084	14·4	41	N·	2·8

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	7th March 1875.								14th March 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·746	45·6	38·4	·155	28·4	50	S. S. W.	...	25·828	40·0	37·9	·207	35·3	83	W.	...
1 ...	·746	45·1	36·9	·130	24·3	43	S. W.	4·5	·806	39·0	36·9	·198	34·2	83	W. N. W.	2·0
2 ...	·756	44·1	34·9	·103	19·0	36	S. S. W.	9·9	·811	38·8	36·9	·201	34·6	84	W. N. W.	5·0
3 ...	·786	44·1	33·9	·085	14·6	29	W.	5·5	·817	38·8	36·9	·201	34·6	84	W. N. W.	3·0
4 ...	·812	43·1	32·9	·077	12·4	28	S. W.	3·2	·823	37·5	36·4	·205	35·1	91	W. N. W.	2·5
5 ...	·835	42·1	32·4	·079	13·0	30	W.	3·7	·810	36·0	34·7	·189	33·1	89	N. W.	1·4
6 ...	·860	38·5	29·9	·083	14·1	35	W.	4·0	·811	34·0	33·4	·187	32·7	95	W. S. W.	1·9
7 ...	·877	45·6	32·4	·040	?	13	S. W.	2·8	·803	38·0	35·9	·190	33·2	83	W.	2·7
8 ...	·889	47·1	37·1	·112	20·9	34	S. S. W.	3·5	·812	41·0	38·9	·216	36·4	84	N. N. E.	1·3
9 ...	·874	55·1	39·9	·078	12·8	18	S. S. W.	3·2	·820	45·7	40·1	·189	33·1	61	S. E.	1·5
10 ...	·867	62·1	45·0	·107	19·9	19	S. S. W.	5·0	·807	51·1	44·0	·209	35·6	56	W. S. W.	0·5
11 ...	·851	61·1	43·0	·075	11·8	14	S. E.	2·7	·790	53·1	44·8	·205	35·1	51	W. N. W.	0·5
12 ...	·824	61·6	41·4	·036	?	6	S. E.	1·4	·780	56·1	46·0	·197	34·1	44	W.	3·6
13 ...	·777	63·1	43·5	·063	8·0	11	S. E.	1·6	·770	51·1	44·0	·209	35·6	56	W. N. W.	15·6
14 ...	·743	64·6	44·0	·057	5·7	9	E.	0·7	·766	50·1	43·0	·199	34·3	55	W.	10·0
15 ...	·715	65·1	44·0	·051	3·3	8	E. N. E.	4·2	·774	49·1	42·5	·200	34·5	57	W.	9·5
16 ...	·703	64·1	44·0	·063	8·0	11	E. S. E.	4·1	·787	45·3	40·9	·210	35·7	70	W.	10·1
17 ...	·693	59·1	40·9	·054	4·5	11	N. E.	2·2	·797	43·9	39·7	·200	34·5	70	W. N. W.	10·2
18 ...	·696	54·1	38·9	·069	10·0	17	N. E.	6·9	·833	42·3	38·8	·201	34·6	74	W. N. W.	10·9
19 ...	·698	51·1	36·9	·063	8·0	17	N. E.	2·3	·851	42·1	38·4	·194	33·7	72	W. N. W.	9·5
20 ...	·701	46·1	34·9	·081	13·6	26	N. E.	3·0	·876	41·0	38·4	·206	35·2	80	N. W.	9·5
21 ...	·706	46·1	33·9	·062	7·6	20	N. E.	1·5	·894	40·5	38·4	·212	35·9	83	W.	7·0
22 ...	·720	43·1	31·9	·058	6·1	21	N. W.	0·9	·913	40·0	38·4	·218	36·7	87	W. N. W.	5·0
23 ...	·728	40·0	30·9	·085	14·7	34	W.	1·5	·940	39·0	36·9	·198	34·2	83	W. N. W.	3·2
24 ...	·738	38·0	29·9	·088	15·4	38	W.	2·8	·952	38·3	36·1	·191	33·3	83	W.	2·2

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st March 1875.								28th March 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
21	25·967	47·1	36·9	·108	20·1	33	S. W.	...	26·117	45·9	40·5	·195	33·8	63	N.	...
1 ...	·961	44·1	35·9	·122	22·9	42	S. W.	2·1	·135	45·1	39·9	·191	33·3	64	N. N. E.	4·9
2 ...	·919	41·0	34·4	·127	23·8	49	N.	1·1	·135	45·1	39 9	·191	33·3	64	N.	3·1
3 ...	·947	39·0	32·9	·122	22·9	51	N.	0·7	·149	44·3	38·4	·170	30·5	58	N. W.	2·7
4 ...	·919	39·0	32·4	·113	21·1	47	S.	1·3	·151	44·0	37·9	·163	29·5	56	N. W.	1·7
5 ...	·967	38·0	31·9	·114	21·3	50	S.	1·0	·147	43·6	37·4	·158	28·8	55	N. W.	0·1
6 ...	·982	36·5	30·9	·120	22·5	56	W.	0·9	·140	43·1	36·9	·153	28·0	55	N. W.	0·1
7 ...	26·012	41·1	36·9	·142	26·4	49	W. S. W.	2·2	·133	44·1	38·4	·172	30·8	59	N. W.	0·3
8 ...	·008	54·1	44·0	·175	31·2	42	W. S. W.	2·1	·127	45·1	39·9	·191	33.3	61	N. N. W.	0·8
9 ...	·012	62·9	47·0	·144	26·7	25	W.	2·3	·117	47·1	37·9	·128	24·0	40	N. N. W.	1·0
10 ...	·008	67·6	49 5	·150	27·6	22	N. N. W.	4·8	·120	49·1	38·9	·126	23·6	36	N. N. W.	1·2
11 ...	25·989	72·1	51·0	·135	25·2	17	S. S. W.	2·7	·103	51·1	41·7	·161	29·3	43	N. N. W.	1·7
12 ...	·960	73·1	52·0	·149	27·5	18	S. E.	2·5	·076	54·1	44·0	·175	31·2	42	W. N. W.	1·5
13 ...	·930	73·1	50·5	·112	20 9	13	N. E.	3·2	·018	56·1	45·5	·186	32·6	41	N. W.	2·0
14 ...	·916	73·1	50·8	·119	22·3	16	N.	3·6	·018	57·1	46·5	·198	34·2	42	N. N. W.	0·9
15 ...	·912	74·1	52·0	·138	25 7	16	E.	2·8	25·994	55·1	45·2	·191	33·3	44	S. E.	3·0
16 ...	·918	71·1	50·0	·122	22·9	16	N. W.	2·4	·984	55·0	45·5	·199	34·3	45	S. E.	2·3
17 ...	·956	67·3	48 2	·122	22·9	18	N.	1·2	·982	53·3	44·0	·184	32·3	45	S. E.	1·0
18 ...	·961	63·3	47·9	·161	29·3	28	N. N. E.	0 8	·984	53·0	43·5	·177	31·4	43	S.	0·2
19 ...	26·000	61·1	46·5	·152	27·9	28	N. N. E.	0·8	26·010	52·3	43·0	·174	31·0	44	S.	0·5
20 ...	·032	59·6	45·2	·140	26·0	27	W. N. W.	1·2	·05	51·6	42·5	·171	30·6	44	S.	0·5
21 ...	·018	56·6	43 0	·126	23·6	27	N. N. W.	2·2	·057	50·1	42·0	·177	31·4	49	W. S. W.	1·6
22 ...	·063	55·1	40·0	·099	18·2	23	N. N. W.	1·1	·057	49·1	40·9	·167	30·1	48	W. N. W.	1·7
23 ...	·067	51·1	38·9	·103	19·0	28	N. N. W.	0·4	·067	48·6	40·4	·162	29·4	47	W. N. W.	0·2
24 ...	·073	49·1	37·9	·106	19·7	30	W.	0·3	·075	48·1	40·7	·174	31·0	52	W. N. W.	0·4

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	7th April 1876.								14th April 1876.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·846	56·6	43·0	·136	23·6	27	N. E.	...	25·802	57·1	45·0	·164	29·7	35	W.	...
1 ...	·865	54·1	42·0	·132	24·7	31	W. N. W.	2·4	·793	55·1	42·0	·121	22·7	28	W. N. W.	3·8
2 ...	·887	53·1	41·4	·133	24·9	32	W. N. W.	3·3	·793	56·1	43·0	·131	24·5	29	W. N. W.	3·5
3 ...	·911	52·1	40·1	·117	22·0	30	N. W.	6·1	·793	57·1	44·2	·146	27·0	31	N. N. W.	6·4
4 ...	·930	51·1	39·8	·121	22·7	33	W. N. W.	3·7	·797	56·6	44·0	·147	27·2	32	N. W.	5·0
5 ...	·950	50·1	38·9	·115	21·5	32	N. N. W.	3·8	·813	56·3	43·8	·147	27·2	32	N. W.	6·3
6 ...	·992	49·1	38·9	·126	23·6	36	N. N. W.	3·7	·826	55·3	43·5	·151	27·8	34	N. W.	3·9
7 ...	26·007	51·6	40·4	·128	24·0	33	N.	3·8	·834	56·1	45·0	·175	31·1	39	W. N. W.	2·6
8 ...	·028	54·6	42·0	·126	23·6	30	N.	3·4	·843	62·1	50·0	·224	37·3	40	W. N. W.	2·9
9 ...	·063	56·9	42·8	·118	22·2	25	N. N. E.	3·0	·830	65·1	50·0	·190	33·2	31	W. N. W.	5·2
10 ...	·067	60·1	45·0	·130	24·4	25	N. N. E.	2·5	·823	70·6	52·0	·177	31·4	24	N. N. W.	6·7
11 ...	·062	63·1	46·0	·118	22·2	21	E. N. E.	2·1	·822	70·6	50·5	·140	26·0	18	W. N. W.	6·4
12 ...	·037	66·3	47·5	·117	22·0	18	N.	2·6	·812	72·1	51·5	·148	27·3	18	N. N. W.	4·0
13 ...	·009	67·6	49·0	·137	25·6	21	E. N. E.	2·5	·797	73·1	52·0	·149	27·5	18	N. N. W.	2·8
14 ...	25·983	67·9	49·0	·134	25·0	20	S. W.	2·2	·782	74·1	51·8	·133	24·9	16	N. N. W.	1·7
15 ...	·977	67·1	48·5	·131	24·5	20	N. E.	3·2	·772	73·6	51·5	·131	24·5	15	N. E.	1·1
16 ...	·971	64·6	47·0	·125	23·6	21	N. N. E.	4·1	·778	73·6	51·5	·131	24·5	15	E.	0·4
17 ...	·974	62·3	45·8	·122	22·9	22	E. N. E.	3·4	·796	70·1	51·0	·158	28·8	22	E.	0·9
18 ...	·986	60·3	44·8	·124	23·2	24	N. E.	2·3	·803	67·6	50·0	·162	29·4	24	E.	0·4
19 ...	·998	59·1	43·5	·108	20·0	21	N. N. E.	2·2	·813	63·1	49·0	·189	33·0	33	E.	0·5
20 ...	26·024	57·6	41·8	·090	16·0	20	N. N. E.	2·4	·837	59·1	48·0	·210	35·7	42	E.	0·1
21 ...	·034	56·1	41·4	·099	18·2	22	E. S. E.	1·4	·847	58·1	47·0	·198	34·2	41	E.	0·1
22 ...	·046	54·0	40·4	·100	18·4	24	E. S. E.	0·9	·865	54·6	45·0	·192	33·4	46	...	0·0
23 ...	·030	53·5	39·9	·095	17·2	23	E. S. E.	0·9	·860	54·4	45·0	·194	33·7	46	...	0·0
24 ...	·028	53·0	39·9	·101	18·6	25	E. S. E.	0·7	·856	54·1	44·3	·182	32·1	43	E.	0·2

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st April 1875.								28th April 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind.		Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind.	
							Direction.	Velocity.							Direction.	Velocity.
21 ...	25·900	54·3	45·5	·207	35·3	48	E. S. E.	...	26·130	57·1	47·0	·209	35·6	45	S. E.	...
1 ...	·899	52·1	44·0	·198	34·2	51	E. S. E.	0·1	·122	56·1	47·0	·221	37·0	49	S. E.	2·3
2 ...	·891	50·6	42·0	·171	30·6	46	E. S. E.	0·1	·122	51·1	46·0	·220	36·9	53	S. S. W.	0·9
3 ...	·885	49·6	41·4	·172	30·8	48	W. S. W.	0·9	·117	53·6	47·0	·249	40·1	61	N. N. E.	0·4
4 ...	·895	52·6	40·4	·117	22·0	29	W.	2·7	·115	52·1	46·9	·262	41·4	69	N. W.	2·2
5 ...	·903	52·5	40·2	·114	21·3	29	W. S. W.	5·8	·125	52·3	47·0	·264	41·6	68	N. W.	2·0
6 ...	·913	54·1	42·0	·132	24·7	31	W. S. W.	0·7	·139	53·1	48·0	·278	43·0	69	N. W.	1·2
7 ...	·928	59·6	45·5	·147	27·2	28	W. S. W.	3·5	·150	56·1	50·5	·305	45·4	68	N. E.	1·0
8 ...	·935	67·6	51·5	·199	34·3	29	W. S. W.	2·9	·159	61·1	52·5	·298	44·8	55	N. E.	3·1
9 ...	·940	76·7	55·1	·189	33·0	21	W. S. W.	1·3	·156	66·6	54·0	·275	42·7	42	E. S. E.	2·4
10 ...	·923	82·2	57·6	·194	33·8	17	N. W.	1·7	·139	69·1	53·5	·226	37·6	32	S. W.	3·4
11 ...	·902	85·4	58·6	·187	32·8	15	N. W.	1·7	·117	71·1	55·1	·252	40·4	33	S. S. E.	2·6
12 ...	·875	86·7	58·6	·172	30·8	13	E. S. E.	1·8	·098	72·6	55·1	·235	38·6	29	S. S. E.	3·2
13 ...	·818	87·2	57·9	·146	27·0	12	E. S E.	3·3	·078	72·6	55·1	·235	38·6	29	S. S. E.	1·9
14 ...	·820	87·7	57·9	·140	26·0	11	E. S. E.	2·1	·052	73·6	55·6	·237	38·8	28	S. S. E.	1·9
15 ...	·781	87·7	57·1	·118	22·1	9	S. E.	2·3	·034	73·1	55·6	·243	39·5	29	S. S. E.	2·3
16 ...	·773	87·7	57·1	·118	22·1	9	S. E.	1·5	·028	71·6	54·5	·232	38·3	30	S. S. E.	2·0
17 ...	·761	85·2	57·1	·147	27·2	12	S. E.	0·3	·022	68·1	54·0	·258	41·1	38	S. S. E.	1·0
18 ...	·761	75·2	56·1	·233	38·4	27	S. E.	0·1	·019	64·1	50·0	·202	34·7	34	S. S. E.	0·2
19 ...	·775	67·9	52·0	·208	35·5	30	...	0·0	·020	59·9	50·0	·250	40·2	49	...	0·0
20 ...	·784	64·1	50·0	·202	34·7	34	...	0·0	·032	58·1	49·5	·258	41·4	53	S. S. E.	0·1
21 ...	·797	61·6	48·0	·201	35·0	37	...	0·0	·037	57·1	48·0	·233	38·4	50	...	0·0
22 ...	·803	61·1	48·5	·200	34·5	36	S. E.	0·1	·039	54·6	47·5	·250	40·2	58	...	0·0
23 ...	·801	60·1	46·5	·164	29·7	31	S.	0·8	·013	54·1	47·0	·243	39·5	58	S. S. E.	0·7
24 ...	·802	56·1	45·0	·175	31·1	39	S.	0·5	·031	53·9	46·5	·234	38·5	56	S. S. E.	0·3

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	7th May 1875.								14th May 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·801	67·6	52·0	·211	35·8	31	N. W.	...	26·073	54·1	45·0	·197	34·1	47	W. N. W.	...
1 ...	·801	66·6	51·5	·210	35·7	32	N. W.	7·1	·049	53·6	44·9	·201	34·6	49	W.	2·8
2 ...	·803	64·1	51·0	·226	37·6	38	N. W.	4·2	·047	52·1	44·8	·216	36·4	56	W.	4·6
3 ...	·808	59·6	49·5	·241	39·3	47	W. N. W.	2·4	·053	50·6	44·7	·231	38·1	63	W.	5·5
4 ...	·813	56·6	48·0	·239	39·0	52	W.	0·6	·053	50·1	44·5	·232	38·2	64	W. N. W.	4·2
5 ...	·808	57·1	49·0	·257	40·9	55	W.	0·3	·062	49·1	44·0	·232	38·2	67	W.	4·5
6 ...	·807	63·6	55·1	·336	48·0	57	W.	1·5	·072	49·3	44·5	·241	39·2	69	W. N. W.	5·3
7 ...	·801	68·1	55·6	·299	44·9	43	E. S. E.	3·0	·093	49·3	45·0	·253	40.5	72	S. E.	5·3
8 ...	·793	71·6	55·6	·260	41·2	33	E. S. E.	5·2	·103	49·3	45·0	·253	40·5	72	...	0·0
9 ...	·772	76·2	57·1	·249	40·1	28	E.	6·3	·110	48·3	45·5	·275	42·7	81	S. E.	0·5
10 ...	·760	78·7	58·6	·264	41·7	27	E. S. E.	4·1	·116	49·5	46·5	·284	43·5	80	S. E.	0·2
11 ...	·723	80·2	58·6	·246	39·8	24	S. E.	2·7	·115	48·1	45·5	.277	42·9	83	E. N. E.	1·0
12 ...	·689	82·7	59·0	·232	38·3	21	S.	2·1	·111	48·3	45·2	·268	42·0	79	N. N. E.	1·6
13 ...	·665	79·7	56·6	·196	34·0	19	N. N. W.	2·1	·097	47·6	45·5	·283	43·4	86	N.	1·9
14 ...	·653	76·2	56·6	·236	38·7	26	W. N. W.	3·4	·101	47·3	45·5	·287	43·8	88	N. N. E	2·1
15 ...	·708	69·6	52·0	·189	33·0	26	N.	8·0	·101	48·6	45·8	·278	43·0	82	N. W.	3·1
16 ...	·728	60·1	49·0	·120	22·5	17	N. W.	9·6	·115	48·1	45·8	·284	43·0	25	N. N. W.	4·4
17 ...	·763	66·1	47·0	·108	20·0	17	N. W.	12·0	·129	48·1	46·0	·288	43·5	86	N. W.	3·0
18 ...	·803	64·6	45·0	·079	13·0	13	W.	17·5	·143	47·1	45·2	·282	43·3	87	W. N. W.	3·8
19 ...	·815	62·6	44·2	·084	14·4	14	W.	15·9	·159	46·6	45·0	·283	43·4	89	W. N. W.	3·8
20 ...	·869	61·6	43 5	·080	13·2	14	W.	4·6	·179	46·1	44·0	·266	41·8	86	W.	3·5
21 ...	·889	60·6	43·0	·081	13·6	15	W. N. W.	16·3	·197	45·1	43·5	·266	41·8	89	W.	2·0
22 ...	·915	59·1	42·0	·076	12·2	15	W.	10·0	·187	45·1	43·0	·256	40·8	85	W. N. W.	3·0
23 ...	·824	58·1	40·9	·066	9·0	14	W.	5·7	·189	45·1	42·5	·245	39·7	81	W. N. W.	4·0
24 ...	·819	57·1	40·9	·077	12·4	16	W.	3·5	·169	45·1	42·0	·233	38·4	78	W. N. W.	1·5

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st May 1875.								25th May 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·818	67·6	51·0	·186	32·6	28	W.	...	25·940	70·6	55·1	·257	40·9	34	N.	...
1 ...	·809	67·6	51·0	·186	32·6	28	W.	3·1	·939	68·1	55·1	·285	43·6	42	N. N. W.	4·5
2 ...	·801	64·1	49·0	·177	31·4	30	W.	2·5	·945	68·1	53·5	·245	39·7	35	W.	1·9
3 ...	·799	58·1	48·0	·222	37·1	46	S.	0·3	·945	67·9	52·5	·222	37·1	32	N. N. W.	3·1
4 ...	·797	58·1	47·5	·210	35·7	43	...	0·0	·947	65·1	53·5	·279	43·1	45	N. W.	5·2
5 ...	·802	55·6	47·0	·226	37·6	51	S.	0·1	·952	64·1	54·0	·303	45·2	51	N. W.	3·1
6 ...	·813	60·6	49·0	·218	36·6	41	W.	2·0	·956	65·1	54·0	·292	44·3	47	N. W.	4·1
7 ...	·815	68·6	54·9	·276	42·8	40	W.	3·6	·956	67·1	57·1	·351	49·2	53	N. W.	2·8
8 ...	·819	75·7	58·1	·283	43·4	32	W.	1·9	·950	71·1	58·1	·333	47·8	44	N. N. W.	3·4
9 ...	·817	84·2	63·2	·334	38·5	29	N. N. W.	1·5	·947	74·1	56·1	·245	39·7	29	N. N. W.	2·3
10 ...	·809	88·2	61·6	·242	39·2	18	N. W.	2·6	·933	78·2	58·1	·255	40·7	27	N. N. W.	2·3
11 ...	·796	91·3	62·2	·222	37·1	15	N. W.	2·7	·920	80·5	59·1	·257	40·9	24	W. N. W.	2·3
12 ...	·773	94·3	64·2	·252	40·4	16	N. W.	2·3	·902	83·2	59·1	·226	37·6	20	N. W.	2·4
13 ...	·738	96·3	63·2	·196	34·0	12	E.	1·8	·881	84·2	59·1	·215	36·3	18	N. N. E.	0·8
14 ...	·709	96·5	62·2	·163	29·5	10	S.	1·4	·851	85·2	59·1	·203	34·8	17	N.	0·5
15 ...	·685	96·8	63·2	·191	33·3	11	E. N. E.	1·9	·827	85·2	58·1	·175	31·2	15	N.	0·2
16 ...	·658	96·3	62·7	·181	31·9	10	E. S. E.	1·6	·812	83·0	58·1	·200	34·4	17	...	0·0
17 ...	·641	93·3	62·2	·199	34·3	13	E.	0·4	·806	80·4	58·9	·252	40·4	24	N.	0·1
18 ...	·633	87·2	61·9	·263	41·5	21	E. N. E.	0·5	·800	78·2	58·9	·277	42·9	30	N.	0·2
19 ...	·639	79·2	60·1	·300	45·0	30	E. N. E.	0·3	·822	75·2	58·6	·303	45·3	34	N.	0·4
20 ...	·658	76·2	58·1	·278	43·0	31	...	0·0	·832	73·6	57·6	·292	44·3	35	N.	0·2
21 ...	·688	75·2	57·6	·275	42·7	31	E. N. E.	0·4	·846	71·6	56·6	·287	43·8	37	N.	0·1
22 ...	·718	75·2	55·6	·220	35·9	25	N. W.	5·3	·846	71·1	55·1	·252	40·4	33	N.	0·7
23 ...	·728	73·6	54·0	·195	33·8	24	W.	4·9	·838	69·1	54·9	·271	42·3	39	N.	0·3
24 ...	·735	73·1	54·0	·200	34·4	25	N. W.	9·5	·819	65·6	54·0	·286	43·7	46	...	0·0

Table II (continued).—*Hourly observations at Kashghár*

Hours.	7th June 1875.								14th June 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·727	62·1	52·0	·274	42·6	49	W. S. W.	...	25·811	64·1	55·1	·330	47·6	55	N. E.	...
1 ...	·723	60·6	51·0	·266	41·8	50	W. S. W.	0·1	·809	62·6	53·8	·315	46·3	56	S. W.	1·2
2 ...	·715	59·1	49·5	·246	39·8	49	......	0·0	·813	62·6	53·8	·315	46·3	56	N. N. W.	3·2
3 ...	·707	58·6	48·5	·229	37·9	46	W. S. W.	0·9	·814	63·6	54·0	·309	45·8	53	N. N. W.	1·4
4 ...	·714	57·6	47·5	·215	36·3	45	W. S. W.	1·8	·820	63·6	54·0	·309	45·8	53	N.	2·4
5 ...	·738	60·1	47·9	·197	34·1	38	W. S. W.	1·6	·826	62·6	54·5	·334	47·9	59	N. N. E.	0·8
6 ...	·750	63·5	50·5	·222	37·1	37	W.	1·7	·833	63·6	56·1	·363	50·1	62	S. W.	1·5
7 ...	·751	69·6	55·6	·282	43·3	39	N. W.	4·3	·842	70·1	59·1	·374	50·9	51	W.	4·7
8 ...	·746	76·7	59·6	·314	46·2	34	W. N. W.	4·6	·837	75·7	60·6	·355	49·5	40	W.	3·2
9 ...	·731	84·2	61·1	·272	42·4	23	W. N. W.	4·3	·820	79·7	61·6	·339	48·2	33	S.	3·5
10 ...	·728	88·2	61·6	·241	39·2	18	N. N. W.	4·1	·806	82·2	62·7	·341	48·4	31	S. E.	2·9
11 ...	·713	93·3	61·6	·184	32·3	11	N. W.	3·9	·788	84·2	62·7	·318	46·5	27	S. E.	2·3
12 ...	·682	94·8	62·7	·198	34·2	12	N. N. W.	2·8	·768	83·7	63·0	·334	47·8	30	S.	4·1
13 ...	·657	94·8	64·2	·246	39·8	15	N.	1·5	·728	88·7	65·2	·347	48·9	26	S.	4·3
14 ...	·628	96·8	64·2	·223	37·3	13	N. W.	1·2	·715	85·7	62·7	·301	45·1	24	S. E.	4·1
15 ...	·620	95·3	63·2	·208	35·4	13	W.	3·7	·685	86·7	62·7	·290	44·2	23	S.	3·8
16 ...	·618	90·7	63·2	·260	41·2	18	N. W.	5·1	·675	85·7	63·2	·317	46·5	26	S.	2·8
17 ...	·624	90·4	63·2	·263	41·5	19	N. W.	4·4	·667	84·7	61·1	·267	41·9	23	S. S. E.	1·8
18 ...	·640	85·7	60·3	·232	38·2	18	N. W.	4·0	·674	79·7	60·1	·294	44·5	29	S. S. E.	1·7
19 ...	·671	83·4	58·6	·209	35·6	18	N. W.	4·2	·691	75·7	58·3	·289	44·0	32	S. S. E.	0·1
20 ...	·695	80·1	57·1	·205	35·1	20	N. W.	5·5	·731	70·1	57·1	·317	44·5	43	N. E.	1·2
21 ...	·717	79·1	57·1	·217	36·5	22	N. W.	3·8	·766	67·1	55·1	·296	44·6	45	N. E.	3·5
22 ...	·733	77·2	56·1	·210	35·7	23	N. W.	5·5	·805	66·1	55·1	·308	45·7	48	W.	1·8
23 ...	·740	76·7	56·1	·216	36·4	24	N. N. W.	4·7	·801	65·6	55·1	·313	46·1	50	W.	0·2
24 ...	·762	73·4	55·1	·229	37·9	28	N. N. W.	6·4	·794	63·1	54·0	·316	46·3	55	W.	2·3

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st June 1875.								28th June 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected	Vapour tension.	Dew point.	Humidity.	Wind.		Barometer reduced to 32°	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind.	
							Direction.	Velocity.							Direction.	Velocity.
24 ...	25·826	71·1	57·6	·319	46·6	42	N. W.	...	25·783	73·1	58·6	·325	47·1	40	N. W.	...
1 ...	·818	70·1	57·1	·317	46·5	43	W. N. W.	4·3	·773	70·9	58·1	·335	47·9	45	N. W.	0·6
2 ...	·806	69·1	56·6	·315	46·3	44	W. N. W.	3·9	·763	70·6	57·6	·325	47·1	43	N. W.	0·4
3 ...	·796	68·6	56·1	·307	45·6	44	W. N. W.	5·3	·767	69·1	56·1	·301	45·1	42	N. W.	2·6
4 ...	·803	65·1	55·1	·319	46·6	52	W. N. W.	3·5	·777	69·1	55·1	·274	42·6	39	N. W.	1·1
5 ...	·811	64·6	54·8	·320	46·7	53	W. N. W.	3·6	·779	69·1	55·1	·274	42·6	39	N. W.	1·3
6 ...	·816	68·1	57·1	·310	48·4	50	W. N. W.	3·0	·780	71·1	57·1	·306	45·5	40	N. W.	1·6
7 ...	·807	73·1	61·1	·399	52·7	49	N. N. W.	3·8	·777	73·6	60·6	·378	51·2	45	N. W.	2·5
8 ...	·802	78·2	60·1	·312	46·0	33	N. N. W.	4·6	·769	78·7	65·2	·462	56·7	48	W.	2·1
9 ...	·785	82·1	62·7	·342	48·4	31	N. W.	4·8	·759	82·7	65·2	·416	53·8	37	W.	2·2
10 ...	·768	85·2	63·2	·323	46·9	27	N.	4·0	·744	86·2	64·2	·344	48·7	28	W.	1·6
11 ...	·751	88·2	64·2	·321	46·8	24	N. W.	3·7	·721	88·0	64·0	·317	46·5	24	W.	2·6
12 ...	·721	89·7	64·2	·301	45·3	22	N.	3·6	·701	92·3	65·7	·323	47·0	21	W.	0·7
13 ...	·688	92·3	65·2	·307	45·6	20	N.	2·0	·685	90·2	66·0	·357	49·7	26	W.	0·4
14 ...	·643	93·3	65·2	·295	44·6	19	N.	1·8	·663	89·2	66·2	·374	50·9	27	W.	0·4
15 ...	·626	94·3	65·7	·300	45·0	18	N.	1·3	·644	88·2	65·7	·369	50·5	28	W.	0·9
16 ...	·603	93·3	65·4	·301	45·1	19	N. W.	1·0	·639	86·2	65·2	·375	51·0	30	W.	1·4
17 ...	·586	91·3	65·2	·318	46·5	22	W. N. W.	2·7	·645	82·7	65·0	·410	53·4	37	W.	1·6
18 ...	·593	85·7	65·0	·375	51·0	31	W. N. W.	2·8	·652	79·7	64·4	·425	54·4	42	W.	0·9
19 ...	·603	82·7	63·2	·351	49·2	32	W. N. W.	1·3	·654	78·2	64·2	·435	55·1	45	...	0·0
20 ...	·621	83·2	63·2	·346	48·8	31	W. N. W.	0·6	·672	75·7	62·2	·401	52·8	45	...	0·0
21 ...	·635	82·7	61·6	·301	45·3	27	W.	9·5	·681	74·1	61·3	·393	52·3	46	...	0·0
22 ...	·667	80·2	61·1	·318	46·5	31	W. N. W.	9·0	·683	73·1	61·1	·399	52·7	49	...	0·0
23 ...	·701	77·2	60·1	·323	46·9	35	W. N. W.	10·5	·693	72·6	61·1	·401	53·0	51	N. N. W.	0·4
24 ...	·727	72·1	56·6	·281	43·3	35	N. W.	15·7	·691	71·1	60·3	·398	52·6	52	N. N. W.	0·5

TABLE II (continued).—*Hourly observations at Káshghár.*

Hours.	7th July 1875.								14th July 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·755	76·7	64·2	·453	56·2	50	...	...	25·407	74·1	65·2	·514	59·7	61	...	...
1 ...	·761	73·1	62·7	·446	55·7	54	...	0·0	·407	73·1	65·2	·525	60·3	65	...	0 0
2 ...	·751	72·6	62·2	·435	55·1	54	N. N. W.	0·1	·405	73·1	65·2	·525	60·3	65	N. W.	0·1
3 ...	·751	72·3	61·6	·423	54·3	53	N. W.	0·5	·409	73·1	63·7	·476	57·6	58	W.	2 2
4 ...	·760	70·6	60·6	·413	53·6	55	W.	1·1	·423	73·1	63·2	·461	56·7	57	W. N. W.	0·5
5 ...	·789	70·6	64·1	·519	60·0	70	...	0·0	·439	72·6	63·2	·466	57·0	58	W. N. W.	0·2
6 ...	·809	76·2	65·7	·507	59·3	56	...	0·0	·464	73·1	63·2	·461	56·7	57	W. N. W.	0·6
7 ...	·828	78·7	67·5	·540	61·1	55	N. N. W.	0·2	492	75·2	64·2	·470	57·2	54	N. N. W.	2·6
8 ...	·833	84·2	69·1	·532	60·7	46	N. N. W.	0·3	·528	76·7	65·2	·485	58·1	53	N. N. W.	4·1
9 ...	·836	89·7	71·7	·562	62·2	40	N. N. W.	0·8	·540	79·2	66·2	·489	58·4	49	N. N. W.	4·8
10 ...	·833	93·3	73·2	·579	63·1	37	N. N. W.	0·9	·553	80·2	65·2	·445	55·7	43	E.	2·5
11 ...	·834	96·3	73·6	·560	62·1	33	N. N. W.	0·8	·547	83·2	65·7	·426	54·5	37	N. E.	1·7
12 ...	·816	98·3	75·1	·600	64·1	33	N. N. W.	1·8	·540	85·2	66·7	·437	55·2	36	N. E.	1·3
13 ...	·792	99·8	76·6	·644	66·1	34	N. N. W.	1·6	·534	87·2	66·7	·414	53·7	32	N. E.	0·7
14 ...	·763	99·8	76·6	·644	66·1	34	N. N. W.	1·8	·532	85·2	68·2	·488	58·3	41	S. S. E.	0·4
15 ...	·753	99·8	76·6	·644	66·1	34	N .N. W.	1·0	·553	80·7	68·2	·540	71·1	52	N. W.	0·8
16 ...	·737	98·8	76·1	·635	65·7	35	N. N. W.	0·9	·605	79·2	62·2	·360	49·9	36	N.	12 0
17 ...	·731	96·3	75·1	·623	65·2	37	N. N. W.	1·1	·629	68·1	61·6	·472	57·4	69	N. W.	5·7
18 ...	·727	89·2	72·2	·587	63·3	43	N. N. W.	1·8	·680	64·1	59·6	·457	56·4	76	N. W.	15·3
19 ...	·737	86·2	69·7	·530	60·6	42	N. N. W.	2·2	·704	63·1	59·6	·469	57·2	81	N. W.	5·7
20 ...	·758	84·2	69·2	·535	60·8	46	N. E.	1·6	·724	62·1	59·1	·466	57·0	84	W. S. W.	2·4
21 ...	·773	80·7	67·2	·506	59·3	49	N. E.	0·5	·754	59·6	57·6	·450	56·0	88	S.	3·8
22 ...	·788	79·2	65·2	·456	56·4	46	N. E.	0·1	·754	59·1	57·6	·457	56·4	91	S.	4·6
23 ...	·798	79·1	65·1	·454	56·3	46	N. E.	0·2	·752	59·1	57·6	·457	56·4	91	S.	8·8
24 ...	·808	74·1	64·2	·481	57·9	57	N. E.	0·1	·746	58·1	57·1	·454	56·2	94	S. S. E.	4·1

TABLE II (continued).—*Hourly observations at Kashghár.*

Hours.	21st July 1875.								28th July 1875.							
	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.	Barometer reduced to 32°.	Temperature corrected.	Wet bulb corrected.	Vapour tension.	Dew point.	Humidity.	Wind. Direction.	Wind. Velocity.
24 ...	25·593	83·2	65·2	·410	53·4	36	N. W.	...	25·613	75·9	64·5	·472	57·4	53	N. N. W.	...
1 ...	·599	82·7	64·7	·400	52·8	36	N. N. W.	4·1	·634	75·2	64·2	·470	57·2	54	N. N. W.	0·6
2 ...	·605	81·7	64·2	·396	52·5	37	N. W.	6·7	·634	74·1	62·2	·418	54·0	50	N. N. W.	0·8
3 ...	·621	80·2	64·2	·413	53·6	40	N. W.	8·6	·644	72·9	58.1	·312	46·0	39	N. N. W.	5·0
4 ...	·636	77·7	65·2	·473	57·4	50	N. W.	4·6	6·60	73·1	58·1	·310	45·9	38	N. N. W.	1·2
5 ...	·648	77·2	65·0	·473	57·4	51	N. W.	4·2	·676	73·1	58·6	·325	47·1	40	N. N. W.	2·6
6 ...	·674	76·2	64·2	·458	56·5	51	N. W.	4·5	·682	73·3	58·6	·323	47·0	39	N. N. W.	3·5
7 ...	·682	78·4	66·2	·499	58·9	52	N. W.	4·0	·697	77·2	61·6	·367	50·4	39	N. N. W.	3·1
8 ...	·677	83·2	68·2	·511	59·6	45	N. W.	5·0	·719	83·2	65·2	·410	53·4	36	N. N. W.	3·4
9 ...	·677	87·2	68·9	·489	58·4	38	N. W.	5·8	·721	86 2	67·2	·442	5 5·5	36	N. N. W.	4·9
10 ...	·674	88·2	69·2	·489	58·4	37	N. W.	4·3	·711	92·3	70·2	·478	57·7	32	N. N. W.	5·3
11 ...	·656	93·3	71·2	·503	59·1	33	N. W.	3·1	·697	92·3	70·2	·478	57·7	32	...	0·0
12 ...	·638	95·1	73·2	·558	62·0	34	N. W.	1·9	·668	99·1	71·2	·436	55·2	23	N. N. W.	9·1
13 ...	·618	95·3	73·2	·556	61.4	34	N. W.	3·3	·643	100·8	72·2	·454	56·2	23	N. N. W.	1·9
14 ...	·599	95·3	74·2	·595	63·9	36	N. W.	4·2	·617	101·3	72·7	·467	57·0	23	N. N. W.	1·7
15 ...	·583	95·3	73·2	·556	62·0	34	N. W.	5·0	·596	100·3	72·2	·459	56·6	24	N. N. W.	1·4
16 ...	·580	90·7	71·2	·532	60·7	37	N. W.	3·6	·582	98·1	74·7	·581	63·2	32	N. N. W.	2·9
17 ...	·580	87·7	69·7	·512	59·6	39	N. W.	1·7	·565	93·3	75·6	·679	67·7	44	N. N. W.	3 6
18 ...	·583	86·2	68·7	·494	58·6	39	N. W.	0·4	·564	88·7	75·1	·711	69·0	53	N. N. W.	1·7
19 ...	·593	84·4	67·7	·481	57·9	41	...	0·0	·574	80·2	69·2	·581	63·2	57	N. N. W.	1·7
20 ...	·613	84·2	67·7	·483	58·0	41	N. W.	0·2	·583	77·2	65·2	·479	57·8	52	N. N. W.	0·5
21 ...	·619	81·7	67·7	·512	59·6	47	...	0 0	·585	76·7	63·2	·420	54·1	47	...	0·0
22 ...	·629	78·7	67·2	·529	60·5	54	N. W.	1·2	·595	76·2	62·2	·395	52·4	44	N. N. W.	1·5
23 ...	·641	78·2	66·7	·518	60·0	54	N. W.	1·2	·597	75·2	60·1	·346	48·9	40	N. N. W.	0·5
24 ...	·647	76·2	66·2	·524	60·3	58	N. W.	0·7	·585	75·2	60·1	·346	48·9	40	N. N. W.	0·6

III.—*The diurnal variation of the barometer at Simla, by* HENRY F. BLANFORD, *Meteorological Reporter to the Government of India.*

In Lieutenant-Colonel (now General) J. T. Boileau's "Collection of Tables, Astronomical, Meteorological and Magnetical, &c.," printed at Umballa in 1850, is a table (No. XXII) shewing the mean variation of the barometer at hourly intervals in each month, at Simla, above or below the semestral mean for that hour and place. The table was drawn up from the reduced readings of a standard barometer, recorded hourly during the three years, 1843, 1844 and 1845. The observations were made at the even hours of Göttingen time, which fall 29 minutes later than the even hours according to local time.

Boileau's tables have been long out of print, and not having been at any time easily accessible to most persons in Europe, the very valuable data given in table XXII remained comparatively unknown to Meteorologists until Dr. Hann published an abstract of the results in the VIIIth volume of the Journal of the Austrian Meteorological Society. As far as I am aware, the full data have never been republished;* and now that attention is once more directed to the intricate problem of the laws and causes of the diurnal variation of barometric pressure, the very important evidence afforded by the mean monthly variation of the oscillation, at a station 7,071 feet above the sea level, and in a sub-tropical climate, well deserves reproduction and some further notice.

The form of the original table is not very convenient for meteorological purposes, and I have therefore given it in an altered form in Table I; *viz.*, the mean variation of the pressure, at each hour of observation, above or below the mean of each month.

From these data, the co-efficients of Bessel's formula, in its expanded and condensed form, have been computed and are given in Tables II and III. The probable variation for each even hour of local time, computed from the formula, is given in Table IV; and lastly, the instants of maximum and minimum pressure, and the amounts of these above and below the mean, have been calculated to a second approximation by the method proposed by Dr. Jelinek. These are given in Tables V and VI. All these calculations have been made by Babu Brojomohun Rakhit, the chief computer of the Meteorological Office.

Except in July and August, the curves (given on Plate IX,) exhibit uniformly the peculiarity which characterizes the diurnal variation of pressure on mountain peaks, and which was first pointed out, I believe, by Plantamour in the case of the Great St. Bernard. This is, that the early morning minimum is the absolute minimum of the day, the semi-

---

* That is to say, the mean values. The original observations have been published in full.

oscillation of greatest amplitude being between 4 and 10 A. M. The explanation given by Plantamour seems quite satisfactory, *viz.*, that by the expansion of the lower and heated strata resting on the plains, a relatively larger proportion of the whole atmospheric column is lifted above the level of the hill station; and thus the static pressure, at that level, is greater during the day than at night.*

It is probable that this form of oscillation is more marked in the neighbourhood of the plains than in the interior of the mountains. It is at least certain that the character of the diurnal oscillation is subject to much greater variation among mountains and in their vicinity than elsewhere, and there seems reason to believe that a good collection of data bearing on this subject from the Himálaya and Tibet would throw much light on the physical causes of the phenomenon.

* I need hardly remark that I do not regard the double oscillation as due to a variation in static pressure. Nor, while recognizing the interest attaching to Lamont's, Broun's, and Hornstein's investigations, which shew a concomitance between certain features of the barometric oscillation on the one hand and magnetic phenomenon and the sun's rotation, on the other, do I see that the agency of heat may not account satisfactorily for the whole phenomenon. As yet the subject is far from being exhaustively treated.

TABLE I.—*Monthly means and hourly variation of the barometer at Simla from observations at the even hours of Göttingen time reduced to local time.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Mean	23·225	23·198	23·197	23·207	23·112	23·061	23·060	23·101	23·194	23·277	23·293	23·254
Midnight 29 m.	—·002	+·001	+·001	—·002	—·007	—·005	+·014	+·002	—·007	—·006	—·002	—·007
1 h. 29 ,,	—·012	—·012	—·015	—·020	—·024	—·020	—·011	—·015	—·020	—·020	—·016	—·019
2 ,, 29 ,,	—·026	—·032	—·036	—·010	—·010	—·037	—·026	—·029	—·034	—·035	—·032	—·031
3 ,, 29 ,,	—·013	—·018	—·053	—·053	—·051	—·016	—·038	—·040	—·014	—·017	—·013	—·014
4 ,, 29 ,,	—·051	—·053	—·059	—·056	—·048	—·016	—·039	—·010	—·043	—·047	—·047	—·052
5 ,, 29 ,,	—·012	—·016	—·016	—·014	—·035	—·033	—·027	—·029	—·030	—·035	—·035	—·012
6 ,, 29 ,,	—·029	—·027	—·030	—·023	—·013	—·014	—·010	—·013	—·011	—·017	—·016	—·022
7 ,, 29 ,,	—·002	—·002	—·002	+·004	+·013	+·010	+·015	+·012	+·006	+·012	+·014	+·006
8 ,, 29 ,,	+·033	+·030	+·029	+·035	+·039	+·035	+·036	+·034	+·012	+·041	+·013	+·039
9 ,, 29 ,,	+·061	+·057	+·054	+·058	+·059	+·054	+·051	+·052	+·061	+·061	+·064	+·065
10 ,, 29 ,,	+·070	+·070	+·065	+·068	+·068	+·064	+·058	+·059	+·067	+·066	+·069	+·072
11 ,, 29 ,,	+·061	+·064	+·062	+·062	+·064	+·058	+·049	+·050	+·057	+·053	+·052	+·055
Noon 29 ,,	+·031	+·010	+·041	+·014	+·017	+·041	+·032	+·032	+·038	+·029	+·026	+·030
13 ,, 29 ,,	+·008	+·015	+·017	+·023	+·027	+·023	+·011	+·009	+·013	+·003	+·001	+·004
14 ,, 29 ,,	—·012	—·009	—·007	—·004	+·002	0	—·012	—·014	—·013	—·017	—·017	—·014
15 ,, 29 ,,	—·025	—·025	—·024	—·024	—·020	—·019	—·030	—·032	—·028	—·029	—·029	—·028
1 ,, 29 ,,	—·031	—·032	—·032	—·032	—·033	—·035	—·013	—·012	—·035	—·032	—·035	—·034
17 ,, 29 ,,	—·029	—·030	—·029	—·034	—·036	—·036	—·047	—·013	—·035	—·030	—·032	—·033
18 ,, 29 ,,	—·016	—·019	—·018	—·022	—·026	—·026	—·032	—·029	—·023	—·014	—·016	—·015
19 ,, 29 ,,	—·012	—·012	—·010	—·013	—·020	—·023	—·014	—·010	—·008	+·001	—·001	—·001
20 ,, 29 ,,	+·011	+·013	+·017	+·015	+·006	+·003	+·003	+·009	+·011	+·016	+·012	+·015
21 ,, 29 ,,	+·023	+·022	+·027	+·024	+·016	+·015	+·018	+·022	+·019	+·023	+·020	+·023
22 ,, 29 ,,	+·021	+·022	+·027	+·023	+·015	+·017	+·023	+·025	+·018	+·021	+·019	+·022
23 ,, 29 ,,	+·014	+·015	+·018	+·015	+·005	+·011	+·020	+·020	—·002	+·012	+·010	+·012

TABLE II.—*Co-efficients of Bessel's interpolation formulæ for the diurnal oscillation of the barometer at Simla.*

N. B.—Midnight = 0 of the hour angles.

	$U' \sin u'$	$U' \cos u'$	$U'' \sin u''$	$U'' \cos u''$	$U''' \sin u'''$	$U''' \cos u'''$	$U'''' \sin u''''$	$U'''' \cos u''''$
January ...	−·0183	−·0003	+·0297	−·0302	−·0012	+·0071	−·0025	−·0035
February ...	−·0200	−·0017	+·0321	−·0302	−·0015	+·0049	−·0007	−·0020
March ...	−·0194	−·0018	+·0321	−·0299	−·0009	+·0028	−·0006	−·0014
April ...	−·0230	−·0020	+·0318	−·0320	−·0006	+·0009	−·0011	−·0007
May ...	−·0279	+·0030	+·0290	−·0291	−·0003	−·0012	−·0009	−·0003
June ...	−·0241	+·0032	+·0288	−·0271	+·0006	−·0012	−·0006	−·0011
July ...	−·0144	+·0092	+·0292	−·0283	+·0012	−·0007	−·0002	+·0006
August ...	−·0148	+·0066	+·0279	−·0306	−·0009	−·0006	−·0009	−·0008
September ...	−·0222	+·0045	+·0249	−·0317	−·0032	+·0024	−·0020	−·0010
October ...	−·0182	+·0014	+·0236	−·0351	−·0006	+·0039	−·0015	−·0014
November ...	−·0180	+·0039	+·0241	−·0344	+·0001	+·0060	−·0023	−·0010
December ...	−·0189	+·0006	+·0267	−·0346	−·0015	+·0061	−·0035	−·0020
Year ...	−·0199	+·0020	+·0283	−·0311	−·0007	+·0025	−·0014	−·0012

TABLE III.

	U'	u'	U''	u''	U'''	u'''	U''''	u''''
January ...	·0183	269° 1'	·0424	135° 29'	·0072	350° 21'	·0043	216° 13'
February ...	·0201	265° 2'	·0441	133° 17'	·0051	342° 41'	·0021	199° 49'
March ...	·0199	256° 7'	·0439	132° 58'	·0029	342° 12'	·0015	204° 8'
April ...	·0231	264° 59'	·0451	135° 8'	·0010	326° 56'	·0013	236° 36'
May ...	·0281	276° 8'	·0411	135° 4'	·0012	193° 15'	·0009	253° 32'
June ...	·0243	277° 32'	·0395	133° 13'	·0013	153° 49'	·0013	208° 32'
July ...	·0170	302° 31'	·0407	134° 4'	·0014	118° 58'	·0006	340° 28'
August ...	·0162	294° 7'	·0414	137° 42'	·0011	237° 57'	·0012	226° 58'
September ...	·0226	281° 35'	·0403	141° 48'	·0040	306° 33'	·0022	243° 36'
October ...	·0183	274° 26'	·0423	146° 2'	·0039	351° 31'	·0021	226° 58'
November ...	·0184	282° 4'	·0420	145° 0'	·0060	0° 57'	·0025	245° 34'
December ...	·0189	271° 52'	·0437	142° 20'	·0063	346° 31'	·0040	239° 34'
Year ...	·0200	275° 45'	·0421	137° 42'	·0026	344° 21'	·0018	229° 21'

TABLE IV.—*Mean variation of the barometer at the even hours of local time at Simla, computed by Bessel's formula.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Midnight	+·0077	+·0099	+·0112	+·0071	−·0001	+·0047	+·0158	+·0113	−·0025	+·0033	+·0039	+·0028	+·0063
1	−·0074	−·0068	−·0072	−·0122	−·0173	−·0127	+·0005	−·0060	−·0169	−·0140	−·0104	−·0125	−·0101
2	−·0219	−·0248	−·0271	−·0320	−·0314	−·0302	−·0179	−·0230	−·0294	−·0303	−·0252	−·0267	−·0268
3	−·0351	−·0104	−·0138	−·0176	−·0164	−·0125	−·0332	−·0352	−·0382	−·0124	−·0380	−·0388	−·0101
4	−·0449	−·0501	−·0534	−·0551	−·0501	−·0164	−·0100	−·0100	−·0120	−·0175	−·0156	−·0172	−·0469
5	−·0183	−·0508	−·0528	−·0515	−·0132	−·0106	−·0354	−·0354	−·0382	−·0132	−·0126	−·0480	−·0413
6	−·0396	−·0394	−·0103	−·0358	−·0257	−·0250	−·0195	−·0216	−·0248	−·0276	−·0285	−·0357	−·0302
7	−·0163	−·0158	−·0166	−·0098	−·0006	−·0023	+·0032	−·0001	−·0014	−·0019	−·0014	−·0091	−·0059
8	+·0173	+·0157	+·0135	+·0209	+·0272	+·0237	+·0268	+·0245	+·0269	+·0278	+·0304	+·0252	+·0235
9	+·0195	+·0162	+·0121	+·0182	+·0509	+·0166	+·0155	+·0155	+·0520	+·0528	+·0565	+·0552	+·0193
10	+·0681	+·0657	+·0607	+·0616	+·0619	+·0604	+·0550	+·0571	+·0656	+·0646	+·0673	+·0696	+·0635
11	+·0660	+·0677	+·0638	+·0663	+·0666	+·0621	+·0538	+·0560	+·0639	+·0596	+·0603	+·0641	+·0624
12	+·0467	+·0529	+·0518	+·0543	+·0563	+·0517	+·0122	+·0127	+·0183	+·0409	+·0397	+·0436	+·0475
13	+·0200	+·0280	+·0300	+·0330	+·0371	+·0331	+·0227	+·0212	+·0247	+·0158	+·0138	+·0171	+·0247
14	−·0011	+·0018	+·0057	+·0082	+·0134	+·0108	−·0007	−·0028	−·0004	−·0079	−·0098	−·0067	+·0006
15	−·0203	−·0186	−·0148	−·0142	−·0100	−·0105	−·0230	−·0242	−·0212	−·0248	−·0262	−·0234	−·0193
16	−·0285	−·0301	−·0276	−·0297	−·0279	−·0266	−·0390	−·0384	−·0343	−·0329	−·0310	−·0324	−·0319
17	−·0301	−·0322	−·0310	−·0353	−·0366	−·0350	−·0448	−·0128	−·0368	−·0318	−·0338	−·0328	−·0353
18	−·0248	−·0262	−·0251	−·0300	−·0341	−·0338	−·0393	−·0360	−·0290	−·0226	−·0243	−·0247	−·0292
19	−·0135	−·0138	−·0122	−·0158	−·0220	−·0233	−·0248	−·0199	−·0136	−·0079	−·0100	−·0095	−·0155
20	+·0019	+·0017	+·0013	+·0025	−·0054	−·0071	−·0058	+·0001	+·0033	+·0084	+·0054	+·0082	+·0015
21	+·0159	+·0156	+·0189	+·0180	+·0091	+·0088	+·0115	+·0175	+·0154	+·0204	+·0169	+·0210	+·0157
22	+·0225	+·0229	+·0263	+·0250	+·0159	+·0178	+·0224	+·0261	+·0178	+·0238	+·0203	+·0240	+·0221
23	+·0192	+·0209	+·0236	+·0209	+·0124	+·0163	+·0240	+·0234	+·0107	+·0174	+·0153	+·0167	+·0184
Mean	23·225	23·198	23·197	23·207	23·142	23·061	23·069	23·101	23·191	23·277	23·293	23·254	23·185

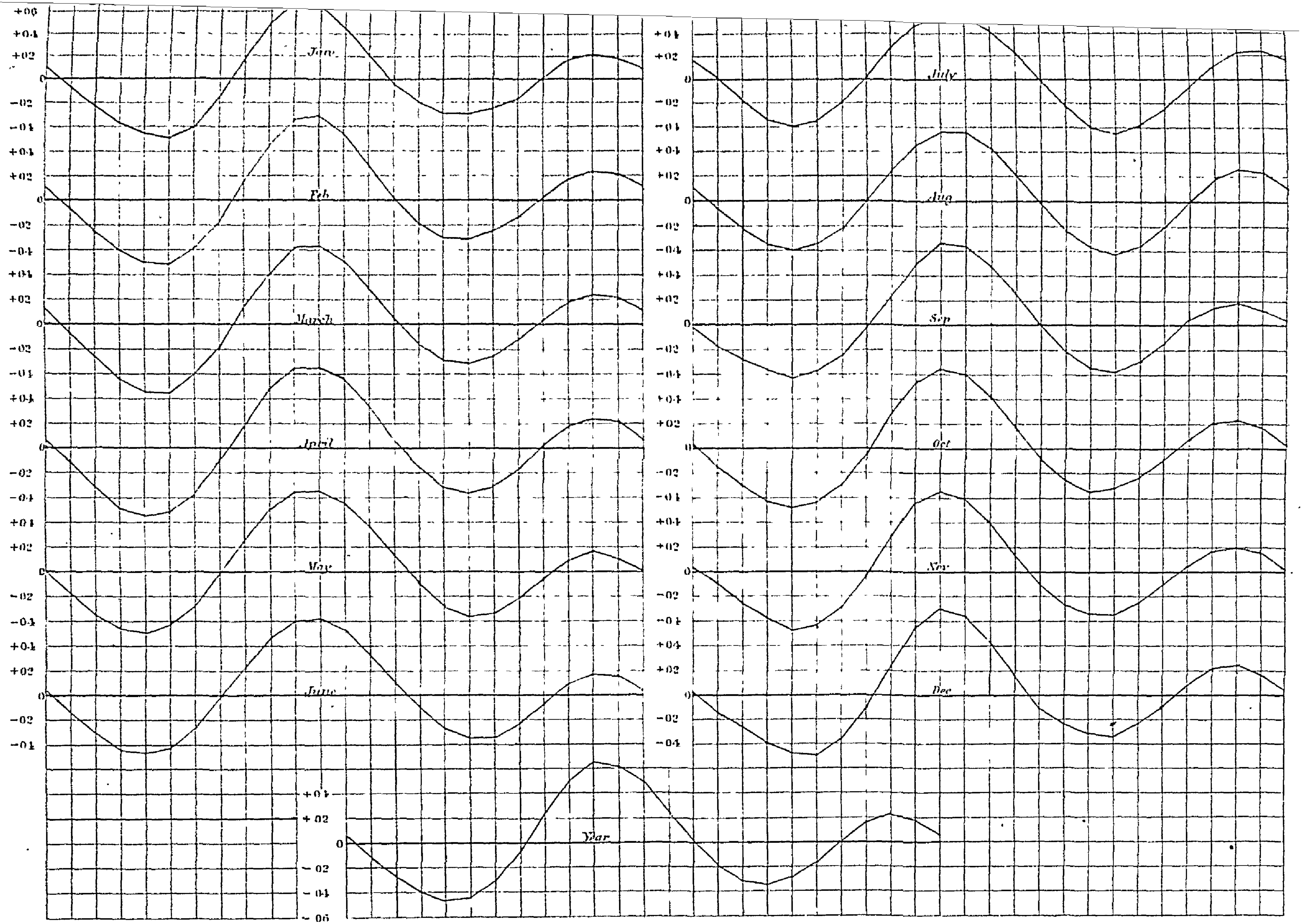
TABLE V—*Diurnal epochs of maximum and minimum pressures.*

	1st Minimum.		1st Maximum.		2nd Minimum.		2nd Maximum.	
	hours.	minutes.	hours.	minutes.	hours.	minutes.	hours.	minutes.
January	4	51	10	24	16	43	22	9
February	4	31	10	36	16	41	22	17
March	4	28	10	41	16	51	22	15
April	4	12	10	37	17	1	22	8
May	3	52	10	38	17	16	22	10
June	3	52	10	37	17	22	22	22
July	4	7	10	23	17	0	22	39
August	4	2	10	25	16	53	22	16
September	4	4	10	23	16	45	21	44
October	4	6	10	12	16	23	21	51
November	4	21	10	6	16	22	21	53
December	4	34	10	13	16	33	21	47
Year	4	15	10	26	16	51	22	8

TABLE VI.—*Diurnal maxima and minima pressures at the epochs in Table V.*

January	—·0185	+·0698	—·0302	+·0227
February	—·0519	+·0691	—·0326	+·0234
March	—·0546	+·0644	—·0311	+·0267
April	—·0554	+·0674	—·0354	+·0251
May	—·0503	+·0675	—·0370	+·0160
June	—·0464	+·0629	—·0357	+·0186
July	—·0101	+·0559	—·0148	+·0246
August	—·0400	+·0582	—·0129	+·0265
September	—·0420	+·0667	—·0372	+·0182
October	—·0176	+·0649	—·0335	+·0240
November	—·0462	+·0675	—·0347	+·0204
December	—·0190	+·0701	—·0337	+·0243
Year	—·0473	+·0650	—·0351	+·0222

Govt. Central Press, No. 106 R. A. & C.—28-11-76.—600.



Lithographed at the Surveyor General's Office, Calcutta, August 1876

IV.—*Storms in Bengal during the year 1876, accompanied with increased atmospheric pressure, and the apparent reversal of the normal diurnal oscillation of the barometer.* *By* J. ELIOT, M.A., *Meteorological Reporter to the Government of Bengal.*

ONE of the most remarkable features in the atmospheric pressure of tropical climates is what is termed the diurnal oscillation. It is now well known that the barometer, even when the atmosphere is apparently quiescent, is in a state of continuous oscillation. There are daily two periods of maximum and two of minimum pressure, the two former occurring about 10 A. M. and 10 P. M., and the latter about 4 A. M. and 4 P. M. The difference between the highest maximum reading, which is usually that of 10 A. M., and the lowest minimum, which is generally at 4 P. M., gives the daily range. If the barometer continues at the same average height,—that is, if the continuous changes of pressure be due only to the causes which produce the continuous diurnal oscillation,—the daily range is found at Calcutta to vary, according to the season, within considerable limits, the mean being ·116″. This represents the effect on the atmospheric pressure, of more or less unknown recurring causes. Much ability has been devoted to the solution of the problem of the diurnal barometric oscillation, but with as yet only a partial measure of success. Two cases occurred in Bengal, during the year 1876, of what may be termed an apparent inversion of the order of barometric oscillation,—that is, of an actual rise of the barometer during the interval from 10 A. M. to 4 P. M., when the most marked fall, due to the diurnal oscillation, usually occurs. Perhaps a study of two failing cases may throw some light in any future consideration of the question.

Instances of such inversion are extremely rare in Bengal. The cause of this is evident from a consideration of the amount of the various changes. The average amount of the diurnal oscillation is ·115″ over the greater part of Northern India. The total barometric change, at any time, is the sum of the change due to the diurnal oscillation and of any irregular changes (usually of longer period) caused by atmospheric disturbances of any kind whatever. Thus, of the latter kind, there are, in Northern India, barometric oscillations of long period, varying, from two or three days to a fortnight, and intimately connected with increasing and diminishing temperature. The range of these oscillations very seldom exceeds ·3″ or ·4″. There are also shorter and more abrupt oscillations due to sudden changes of atmospheric pressure, such as occasionally occur during dust-storms in Northern India, north-westers in Calcutta, or the revolving storms (*tornados*) of certain districts of Bengal. Finally, there are the excessive and rapid changes which occur during the passage of a cyclone. These last are, however, altogether exceptional, and will not be further referred to in the present discussion.

In the two former cases, it is a very unusual circumstance, in Northern India, for the rise or fall of the barometer in the twenty-four hours to exceed ·2″; and, as a rule, it seldom

exceeds ·1″. This change is, in the majority of cases, gradual, and spread nearly uniformly over the twenty-four hours of the day. The rate of change due to these variations is thus less than the rate of fall due to the diurnal oscillation between 10 A. M. and 4 P. M.; and hence, any continuous and more or less regular movement of this kind will not affect the character of the change from 10 A. M. to 4 P. M., but can only either increase or diminish its amount. The only action (omitting the exceptional cases of cyclones and other violent rotatory storms) which can reverse the character of the change from 10 A. M. to 4 P. M., is some sudden and more or less rapid rise of the barometer, greater in amount than the daily range. One of the cases which occurred was due apparently to the descent of a mass of cold air. The other is, as far as can be judged from the meagre returns furnished by all stations except Calcutta, probably an example of the increase of pressure, due to the action which almost invariably attends excessive rainfall, over tropical land areas.

The first occurred on the 17th of June, the actual reversal taking place over a limited area, including Calcutta and Saugor Island. The observing stations in Bengal are, unfortunately, too far apart, to furnish sufficient information for the exact localisation of any limited meteorological phenomenon. The following hourly observations, taken at the Surveyor General's Office and the Meteorological Office, Calcutta, give the elements of the atmospheric changes at that station during the day. The only column which may require explanation is the third column. The curve of the diurnal oscillation for the month of June has been obtained, with considerable exactitude, from the observations of 24 years at Calcutta. Hence, the deviation at each hour of the day from the mean barometric height, due to the diurnal oscillation, is known. The figures thus obtained, for each hour of the day, have been added to or subtracted from the figures of column 2, to give column 3, which thus represents the changes of atmospheric pressure, freed from the effects of the normal diurnal oscillation, and gives approximately the changes due to any other causes acting at the time.

TABLE I.—*Results of hourly observations taken at the Surveyor General's Office, Calcutta, on the 17th June 1876.*

Time.	Barometer reduced to 32°.	Atmospheric pressure corrected for Daily Range.	Dry bulb Thermometer.	Wet bulb Thermometer.	Dry Thermometer above Wet.	Pressure of aqueous vapour.	Wind.	
							Direction.	Miles during previous hour.
Midnight	29·565	·550	85·5	83·6	1·9	1·114	S.	...
1	·548	·544	85·5	83·5	2·0	1·120	S.	8
2	·538	·544	85·4	83·4	2·0	1·116	S.	5
3	·518	·533	85·2	83·2	2·0	1·108	S.	5
4	·523	·540	85·0	83·0	2·0	1·101	S.	4
5	·533	·541	84·8	83·0	1·8	1·104	S. S. E.	4
6	·549	·542	85·3	83·2	2·1	1·107	S.	4
7	·559	·537	86·5	84·0	2·5	1·131	S.	5
8	·576	·552	88·3	84·7	3·6	1·143	S.	9
9	·576	·531	90·5	85·0	5·5	1·128	S. S. W.	13
10	·572	·531	92·1	86·0	6·1	1·159	S. S. W.	5

TABLE I.—*Results of hourly observations taken at the Surveyor General's Office, Calcutta, on the 17th June 1876,*—concluded.

TIME.	Barometer reduced to 32°.	Atmospheric pressure corrected for Daily Range.	Dry bulb Thermometer.	Wet bulb Thermometer.	Dry Thermometer above Wet.	Pressure of aqueous vapour.	WIND. Direction.	WIND. Miles during previous hour.
11	·566	·533	92·5	85·5	7·0	1·128	S. S. W.	7
Noon.	·523	·504	93·7	85·5	8·2	1·112	W.	10
13	·578	·578	81·8	78·8	3·0	·943	E.	15
14	·607	·627	78·5	77·5	1·0	·930	S. E.	20
15	·600	·639	77·5	76·5	1·0	·899	S. S. E.	16
16	·582	·636	78·0	76·7	1·3	·901	E. S. E.	14
17	·589	·644	78·0	76·8	1·2	·905	S. E.	10
18	·595	·640	78·0	76·8	1·2	·905	S. E.	12
19	·590	·615	77·4	76·5	0·9	·900	S. S. E.	9
20	·583	·586	77·4	76·4	1·0	·895	S.	8
21	·599	·585	77·4	76·4	1·0	·895	S.	15
22	·618	·592	77·3	76·3	1·0	·892	S. S. W.	13
23	·626	·601	77·1	76·4	0·7	·899	S.	8

The first minimum of the day occurred between 3 and 4 A. M.; the lowest reading (corrected for temperature) taken at 3 A. M. being 29·518″. The first maximum was at 9 A. M., when the corrected reading was 29·576″. The rise during this period was normal in character and amount. The very slight differences in the figures of column 3, from midnight to 11 A. M., establish the fact of the absence of any irregular disturbing action during this interval. From 9 A. M. the barometer fell in the usual manner until noon, the only important circumstance in the fall being that the amount from 11 A. M. to noon, as is shown by column 3, was in excess of its normal fall. At noon it began to rise rapidly, the actual rise from noon to 2 P. M. being ·084″. It then fell very slightly until 4 P. M., when the corrected reading was 29·582″, being ·006″ higher than at 9 A. M. The Saugor returns present the same feature in a much more marked form. The readings (corrected) taken during the day at that station were—

10 A. M. ... ... 29·593
4 P. M. ... ... 29·646

giving an actual rise of ·053″. Column 3 of the Calcutta observations shows that this was due to an irregular disturbance, producing at that station a virtual abnormal rise of the barometer from 12 to 15 hours (noon to 3 P. M.), amounting to ·135″, and followed by a much slower and gradual fall.

The amount of rain registered at Saugor Island at 4 P. M. was 1·5″, and at 10 A. M. of the following morning ·7″. The rainfall at Calcutta registered at the same times was ·81″ at 4 P. M. on the 17th and ·22″ at 10 A. M. on the 18th. The amount of the fall at Calcutta was thus almost exactly half that at Saugor Island

Returning to the Calcutta hourly observations for the day, it will be observed that the following changes occurred simultaneously during the horary interval noon to 1 P. M.:—

First.—A rise of the barometer from 29·523″ to 29·578″, representing an increase (freed from the effect of the diurnal oscillation) from 29·504″ to 29·578″ or of ·074″.

Second.—A very rapid and decided fall of temperature of the air in the shade, from 93·7° to 81·8°. The diminution of temperature of the air during the hour was thus 11·9°.

Third.—An equally sudden decrease of the tension of the aqueous vapour present in the lowest stratum of the atmosphere, from 1·112″ to ·943″—a change of ·169″, or of 1·68 grains weight of vapour in the cubic foot.

Fourth.—A change of wind direction from west through north to east, accompanied with a considerable increase of wind velocity. This change, as shown by the trace of the Beckley's self-registering anemometer at the Meteorological Office, was almost instantaneous.

These rapid and decided changes in all the elements of the atmospheric condition were followed by a fall of rain, which commenced at 1-10 P. M. and continued for several hours. Unfortunately, the self-registering rain-gauge at the Surveyor General's Office, Calcutta, went out of order almost immediately after the rain began; consequently the continuous record of rainfall for the day is wanting.

The second table gives the actual readings (corrected), taken during the day, at the observing stations in Lower Bengal and along the coast of the Bay of Bengal.

TABLE II.

	Hour.	Barometer.	Temperature.	Wind Direction.	Vapour Tension.	Rain.
Port Blair	10	29·827	84·	S. W.	·993	0·42
"	16	751	84·5	S. W.	·962	
Madras	10	814	88·9	S. W. by W.	·672	0·03
"	16	686	97·9	...	·622	
Akyab	10	740	81·	W.	·958	1·34
"	16	660	82·	S. W.	·941	
False Point	10	622	92·0	W.	·903	...
"	16	550	89·0	S. W.	1·029	
Cuttack	10	544	95·2	W. S. W.	·817	...
"	16	469	97·5	W.	·743	
Sáugor Island	10	594	91·7	S. W.	1·121	2·10
"	16	645	76·0	N. E.	·872	
Chittagong	10	606	87·4	E.	·945	...
"	16	530	85·9	S. W.	·993	
Calcutta	10	572	92·1	S. S. W.	1·160	1·03
"	16	582	78·0	E. by S.	·901	
Jessore	10	590	89·2	S.	1·146	1·21
"	16	584	75·9	S. S. W.	·855	
Dacca	10	619	89·	S.	1·041	1·12
"	16	572	77·8	Calm.	·860	
Silchar	10	629	84·5	E.	·939	...
"	16	484	91·0	E.	·898	

This table indicates that the same characteristics prevailed at Dacca and Jessore as at Calcutta, on the 17th. It is probable that the changes also occurred in the same order as at Calcutta; and that the area, over which the disturbance extended, included the southern portion of the Deltaic area, and stretched to some distance south of the coast.

TABLE III.—*Giving the mean atmospheric pressure, temperature, wind direction, vapour tension, and rainfall, at stations on or near the coast of the Bay of Bengal, from the 10th to 21st of June 1876.*

Station		JUNE 1876. 10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st
PORT BLAIR.	Barometer	29·701	29·685	29·701	29·717	29·778	29·767	29·774	29·780	29·789	29·704	29·808	29·789
	Temperature	82·0	82·0	81·7	81·5	81·0	81·2	80·2	81·7	82·2	82·5	82·2	81·5
	Wind direction ...	S. / W.	S. / S. W.	S. S. W. / S.	S. S. E. / S. S. E.	S. / W.	S. W. / S. W.	S. W. / S. W.	S. W. / S. W.	S. S. W. / S. W.	S. W. / W. S. W.	S. S. W. / S. W.	S. W. / S. W.
	Vapour tension	·929	·940	·948	·975	·931	·971	·962	·977	·950	·937	·842	·965
	Rainfall...	0·08	0·01	0·02	......	0·20	0·42	2·42	0·42	......	0·12	0·09	0·83
MADRAS.	Barometer	29·710	29·679	29·693	29·707	29·729	29·724	29·730	29·701	29·770	29·748	29·749	29·736
	Temperature	86·0	88·3	86·5	84·1	84·2	83·3	85·0	89·1	85·7	87·0	88·2	89·9
	Wind direction ...	W. by S. / S. by E.	S. W. by W. / S. E. by E.	W. by N. / S. E.	W. by S. / E. S. E.	S. W. by W. / S. E.	S. W. by W. / S.	W. S. W. / S. S. W.	S. W. by W. / S. W. by S.	S. W. by W. / S. W. by S.	W. by S. / S. W. by S.	W. S. W. / S. W.	W. S. W. / S. S. W.
	Vapour tension	·760	·755	·779	·807	·889	·784	·787	·701	·759	·709	·734	·746
	Rainfall	......	......	0·01	1·13	......	0·13	0·53	0·03	......	0·05	......	0·03
AKYAB.	Barometer	29·751	29·725	29·739	29·713	29·730	29·727	29·693	29·703	29·697	29·637	29·673	29·674
	Temperature	79·3	82·0	81·8	82·6	77·7	73·0	77·9	76·9	75·9	77·3	78·6	76·6
	Wind direction ..	S. S. W. / S.	S. / S. W.	S. S. W. / S.	S. / S.	S. / S.	W. / S.	E. S. E. / W.	W. / S. W.	S. E. / W.	S. / S.	S. S. W. / S.	S. S. W. / S. S. W.
	Vapour tension	1·069	1·079	1·070	1·075	·975	·889	1·002	·910	·991	·980	1·018	·981
	Rainfall	1·02	0·10	0·07	0·05	1·02	2·37	0·13	1·34	2·63	1·73	0·61	1·64
FALSE POINT.	Barometer	29·630	29·622	29·621	29·661	29·640	29·600	29·571	29·602	29·624	29·501	29·533	29·529
	Temperature	88·9	87·5	88·2	89·5	88·5	89·1	89·2	87·1	83·7	82·9	82·1	84·5
	Wind direction ...	S. W. / S. W.	S. / S.	S. / S.	S. / S.	S. W. / S. W.	S. W. / S. W.	S. W. / S. W.	W. / S. W.	W. / S. W.	W. / W.	W. / N. W.	W. / W.
	Vapour tension	1·059	1·100	1·052	1·030	1·049	1·077	1·008	·930	·936	·922	·867	·947
	Rainfall	......	......	......	......	......	......	......	......	1·50	......	......	......
CUTTACK.	Barometer	29·552	29·524	29·544	29·579	29·517	29·537	29·494	29·513	29·513	29·199	29·474	29·177
	Temperature	91·9	91·8	93·2	91·5	93·3	88·6	91·8	93·1	84·4	82·3	83·3	79·1
	Wind direction ...	S. W. / S.	S. W. / S. S. E.	S. S. W. / S. S. W.	S. S. W. / S. S. W.	S. W. / S. W.	S. S. W. / S. S. E.	S. W. / W.	W. W. / W.	W. / S.	W. S. W. / S. W.	W. S. W. / W. S. W.	S. W. / S. W.
	Vapour tension	·929	·931	·912	·882	·915	·982	·728	·780	·894	·893	·868	·882
	Rainfall	..	......	.. ...	......	......	0·33	......	......	1·56	1·13	......	0·53
SAUGOR ISLAND.	Barometer . ..	29·647	29·610	29·629	29·601	29·635	29·585	29·555	29·606	29·598	29·537	29·480	29·496
	Temperature	84·9	87·5	87·6	87·9	87·7	88·3	88·1	84·1	84·3	83·9	81·2	84·5
	Wind direction ...	S. S. W. / S.	S. / S.	S. / S. S. E.	S. S. W. / S.	S. S. W. / S.	S. S. W. / S. S. W.	S. W. / S. S. W.	S. W. / N. E.	S. W. / S. W.	N. N. W. / S. W.	N. W. / W.	S. W. / S. W.
	Vapour tension	1·020	1·018	1·030	1·014	1·070	1·080	1·063	1·015	1·057	·997	·995	1·018
	Rainfall	0·08	0·70	......	......	......	......	......	2·10	0·03	0·12	0·11	0·30
CHITTAGONG.	Barometer	29·617	29·606	29·619	29·623	29·623	29·577	29·569	29·573	29·575	29·508	29·516	29·547
	Temperature	80·5	83·2	82·6	84·1	84·8	85·0	81·2	82·0	80·8	80·2	78·4	79·2
	Wind direction ...	S. E. / S. W.	S. S. W. / S. W.	S. S. E. / S.	S. S. W. / S. W.	S. / S. S. W.	S. S. E. / S. E.	S. / S. W.	E. / S. W.	W. N. W. / S. S. W.	E. / S. E.	S. E. / E.	S. S. E. / S. S. E.
	Vapour tension	·960	1·021	1·001	1·041	1·054	1·036	·952	·969	·970	·927	·901	·989
	Rainfall	2·17	0·15	0·10	......	0·74	0·04	1·02	......	0·07	0·06	1·58	0·87
CALCUTTA.	Barometer	29·670	29·593	29·608	29·632	29·596	29·547	29·533	29·574	29·578	29·514	29·163	29·479
	Temperature	80·8	86·7	87·1	87·3	87·3	87·0	88·4	83·1	83·5	84·0	82·0	80·0
	Wind direction ...	S. S. W. / S.	S. / S. S. W.	S. S. W. / S. S. E.	S. S. W. / S. S. W.	S. S. W. / S. S. W.	S. / S. by W.	S. by E. / S.	S. S. W. / E. by S.	S. S. W. / S. E.	E. by S. / S. S. E.	S. by W. / S. W.	S. / S.
	Vapour tension	1·032	1·013	1·038	1·015	·982	1·009	1·010	1·013	1·001	·968	1·010	1·007
	Rainfall	0·03	. . . .	0·10	0·02	.. ..	0·03	.. ...	1·03	0·20	2·01	0·27	2·43
JESSORE.	Barometer ...	29·612	29·578	29·506	29·614	29·591	29·516	29·538	29·587	29·558	29·518	29·157	29·102
	Temperature	83·1	87·1	86·1	85·2	85·7	86·1	87·1	78·4	81·6	81·4	81·6	81·9
	Wind direction ...	S. E. / S	S. / S.	S. S. W. / S.	S. W. / S.	S. / S.	S. / S.	S. / S. S. E.	S. / S. S. W.	S. E. / S. E.	S. E. / S. E.	S. E. / calm.	S. / S. S. E.
	Vapour tension .	1·054	1·018	1·019	1·016	1·057	1·056	1·066	1·000	1·045	1·078	1·053	1·040
	Rainfall	0·09	......	......	......	......	......	... .	1·27	......	......	0·59	0·18
DACCA.	Barometer	29·633	29·590	29·613	29·615	29·608	29·560	29·581	29·599	29·587	29·520	29·186	29·192
	Temperature ...		......	......	......	......	......	......	......	......	......	......	......
	Wind direction ...	S. S. E. / S.	S. / S.	S. / S. S. W.	S. / S.	S. / S. S. W.	S. / S.	S. / S. E.	S. / calm.	calm. / S. S. E.	S. S. E. / E. S. E.	E. S. E. / S. S. E.	S. E. / S. S. E.
	Vapour tension	1·064	1·078	·985	1·019	1·046	·998	1·094	·950	·973	1·038	1·036	1·017
	Rainfall	0·06	... .	......	0·01	......	0·10	0·02	1·12	......	0·03	1·67	0·04
SILCHAR.	Barometer	29·639	29·596	29·621	29·437	29·607	29·597	29·580	29·563	29·562	29·517	29·514	29·520
	Temperature	77·0	81·7	81·1	81·6	80·1	74·3	78·9	81·2	84·0	86·4	84·4	83·1
	Wind direction ...	N. / E. S. E.	E. / N.	N. W. / N.	S. S. W. / N. N. E.	E. N. E. / calm.	E. / E.	E. S. E. / E.	E. / E.	W. / W.	calm. / S. S. E.	S. / E.	N. N. E. / N. W.
	Vapour tension	·874	·952	·963	·941	·917	·868	·934	·918	·941	·976	1·014	1·016
	Rainfall... . .	1·51	0·73	1·11	1·13	2·14	5·87	0·71	......	... ..	0·65	0·38	1·04

The third table (*preceding page*) gives the mean daily atmospheric pressure, temperature, wind direction, vapour tension, and rainfall of eleven stations on and near the coast of the Bay of Bengal, for the period June 10th to June 21st. It presents one or two features of importance, which bear indirectly on the question; and which as I believe they have not been noticed before, I shall give more prominently than they perhaps deserve in connection with the present question.

The mean atmospheric pressure at Madras during the month of June obtained from the barometric readings of 7 years is 29·677″, and that for Saugor Island is 29·561″. Hence, the mean baric difference for the month between Saugor Island and Madras is ·116″. Similarly, as the mean atmospheric pressure at Port Blair for the month is 29·718″, the mean baric difference between Saugor Island and Port Blair for the month of June is ·157″.

Referring to the table, the following will be seen to be the daily baric differences for the period in question, the pressure at Saugor Island being always the lower:—

	Madras and Saugor Island.	Port Blair and Saugor Island.
10th	·072	·054
11th	·069	·075
12th	·065	·073
13th	·043	·083
14th	·093	·143
15th	·139	·172
16th	·175	·219
17th	·155	·183
18th	·172	·191
19th	·211	·257
20th	·259	·319
21st	·250	·303

Hence, from the 13th to the 16th, there was a rapid increase in the baric difference between Bengal and the mid-Bay, (as indicated by the above,) when it was considerably above the mean. This was followed by a slight fall until the 18th, after which, it continued to increase rapidly until the 20th, when it was more than double its usual amount. This increase of baric gradient between the mid-Bay and the coast and interior of Bengal, is an almost invariable antecedent and accompaniment of heavy rainfall during the rainy season. It is, moreover, probable, that these variations of baric difference, oscillatory in their character, between the mid-Bay and the coast region of Bengal, determine the periods of exceptionally heavy rainfall along the coast of Bengal. The following three cases, selected at random, will suffice to indicate the connection which appears to exist between the changes of relative pressure for the Bay and Bengal during the rainy season, and the distribution of rainfall along the coast region.

The two following tables give the baric differences for two months—October 1871 and June 1874—and the rainfall at several of the stations at or near the northern coast of the Bay of Bengal.

TABLE IV.—*October 1871.*

	Baric Difference.		Inches of Rainfall.							
	Saugor Island to Port Blair.	Saugor Island to Madras.	Akyab.	Cox's Bazar.	Chittagong.	Noakhally.	Saugor Island.	Cherra Poonjee.	False Point.	Dowlat Khan.
1	— ·027	— ·019	...	...	0·04	...	...	...	...	...
2	— ·028	— ·021	...	...	0·20	0·31	...	...	...	...
3	— ·006	— ·025	...	...	0·21	...	...	...	...	...
4	+ ·010	— ·032	...	...	...	...	...	...	...	...
5	+ ·021	— ·058	...	...	...	...	...	...	...	...
6	— ·003	— ·083	...	...	...	...	...	...	...	...
7	+ ·007	— ·085	...	...	...	...	...	...	...	...
8	+ ·002	— ·060	0·09	...	...	...	...	...	...	...
9	— ·021	— ·066	0·30	...	...	...	...	...	...	...
10	— ·052	— ·084	0·06	0·02	0·12	0·06	...	...	...	...
11	— ·061	— ·029	0·51	0·12	...	0·16	...	0·46	0·30	0·71
12	— ·077	— ·041	0·50	0·40	0·13	1·15	2·02	2·50	1·69	3·10
13	— ·003	+ ·015	0·26	...	1·46	3·42	1·46	7·27	1·80	0·10
14	+ ·037	+ ·044	1·36	...	0·05	0·08	0·04	0·10	...	...
15	+ ·070	+ ·024	...	...	...	0·12	...	...	1·00	0·68
16	+ ·075	+ ·008	...	...	...	0·03	...	0·03	...	0·10
17	+ ·066	— ·008	...	...	0·37	...	...	...	...	...
18	+ ·052	+ ·015	...	0·09	...	...	...	...	...	...
19	+ ·054	+ ·001	...	...	...	...	...	...	...	...
20	+ ·101	+ ·008	...	...	...	...	...	...	...	...
21	+ ·123	+ ·022	...	...	...	...	...	...	...	...
22	+ ·115	+ ·039	...	...	...	...	...	...	...	...
23	+ ·074	+ ·070	2·84	...	0·37	0·07	0·50	1·05	0·15	...
24	+ ·004	+ ·047	0·06	0·07	...	0·49	11·55	...	7·40	0·20
25	— ·109	— ·066	2·98	0·80	2·08	4·89	5·74	0·75	...	8·85
26	— ·088	— ·106	2·54	4·05	3·41	6·70	...	6·80	...	0·90
27	+ ·011	— ·026	0·97	0·02	...	...	...	0·03	...	...
28	+ ·056	— ·015	0·37	...	...	...	...	...	...	...
29	+ ·099	— ·014	...	...	...	...	...	...	...	...
30	+ ·124	+ ·007	...	...	...	...	...	...	...	...
31	+ ·120	+ ·038	...	...	...	...	...	...	...	...

TABLE V.—*June 1874.*

Mean for month.	Baric Difference.			Rainfall.					
	Saugor Island to Port Blair.	Saugor Island to Madras.	Akyab to Port Blair.	Akyab.	Cox's Bazar.	Chittagong.	Noakhally.	Saugor Island.	Dacca.
1	− ·001	+ ·030	+ ·024	0·02	...	...	...	...	...
2	+ ·012	+ ·046	+ ·053	...	...	...	...	...	...
3	+ ·020	+ ·024	+ ·047	0·14	...	...	...	...	...
4	+ ·004	+ ·018	+ ·021	...	...	0·50	...	...	...
5	+ ·020	+ ·012	+ ·051	1·72	...	0·29	0·97	...	...
6	+ ·031	+ ·017	+ ·067	0·52	...	0·34	0·06	...	0·07
7	+ ·022	− ·049	+ ·077	3·72	0·53	1·03	...	0·27	0·01
8	+ ·014	− ·023	+ ·051	...	0·78	0·87	0·01	2·89	...
9	+ ·038	+ ·001	+ ·076	...	0·06	0·12	0·31	0·73	0·02
10	+ ·017	− ·055	+ ·042	0·32	...	1·93	0·11	0·86	0·38
11	− ·013	− ·026	+ ·010	0·16	0·25	0·04	...	0·25	...
12	− ·034	− ·002	+ ·015	1·38	0·09	0·01	0·14	0·10	...
13	− ·017	+ ·017	+ ·017	...	0·60	0·03	...	...	...
14	− ·037	− ·029	+ ·022	...	...	0·25	0·06	0·03	0·01
15	− ·179	− ·142	+ ·045	1·95	...	...	...	0·40	0·25
16	− ·258	− ·237	− ·080	1·40	...	0·05	0·34	0·14	0·01
17	− ·324	− ·285	− ·074	3·73	0·35	0·38	0·13	0·99	...
18	− ·256	− ·172	− ·052	3·01	5·02	1·34	3·35	3·44	1·16
19	− ·183	− ·129	− ·043	2·90	5·08	0·94	1·80	0·39	0·31
20	− ·155	− ·095	− ·067	1·14	0·50	0·37	2·24	...	1·50
21	− ·171	− ·113	− ·101	1·30	0·50	...	0·91	...	0·01
22	− ·204	− ·152	− ·102	0·83	0·12	0·18	...	...	0·08
23	− ·252	− ·204	− ·097	4·18	1·67	0·08	0·45	...	...
24	− ·261	− ·217	− ·140	3·96	3·67	1·50	0·51	1·18	0·19
25	− ·316	− ·296	− ·149	1·24	3·25	2·74	1·50	0·10	0·39
26	− ·309	− ·297	− ·160	3·11	3·01	0·45	0·37	0·11	0·97
27	− ·277	− ·226	− ·133	1·74	2·78	2·21	0·88	...	0·46
28	− ·182	− ·137	− ·050	0·91	0·60	0·23	3·68	...	0·46
29	− ·143	− ·095	− ·062	0·03	0·29	...	0·85	...	...
30	− ·069	− ·040	− ·017	..	...	...	0·21	2·60	0·12

Table VI gives the daily baric differences between Saugor Island and Port Blair, (as a rough approximation to the baric differences between Bengal and the mid-Bay,) during the rainy months of 1875, and the average daily rainfall over four divisions of the Bengal Presidency, *viz.*, the Chittagong, Dacca, Presidency, and Burdwan Divisions. The figures for rainfall are the arithmetical means of the rainfall returns obtained from the numerous revenue stations in these divisions.

TABLE VI.

May 1875.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Baric difference. Saugor Island to Port Blair (Mean for month —·058.)	—·123	—·055	—·001	+·015	—·016	—·071	—·067	—·096	—·092	—·129	—·110	—·100	—·007	—·065	—·073	—·096	—·012	—·010	—·001	—·021	—·020	+·002	—·042	—·071	—·101	—·096	—·078	—·011	—·006	—·027	—·019
RAINFALL. Burdwan ...	...	0·71	0·57	0·23	0·32	0·23	0·01	0·02	0·14	0·29	0·31	0·32	0·17	0·03	...	0·06	0·32	0·34	0·11	0·03	0·01	0·05	0·13	0·18	0·33	0·11	0·50	0·01	0·05	0·04	0·02
Presidency	0·01	0·30	0·73	0·32	0·12	0·15	0·02	0·09	0·23	0·12	0·21	0·20	0·35	0·07	...	0·05	0·17	0·12	0·10	0·22	0·03	0·22	0·02	0·18	0·25	0·24	0·29	0·01	0·12	0·23	0·04
Dacca ...	0·33	0·77	0·11	0·21	0·23	0·02	...	0·05	0·13	0·25	0·14	0·21	0·91	0·37	0·12	0·11	0·23	0·27	0·11	0·21	0·11	0·03	0·08	0·32	0·06	0·26	0·10	0·09	0·17	0·07	0·26
Chittagong	1·61	0·35	...	...	0·34	...	...	0·05	...	0·03	0·07	0·55	0·53	0·76	0·02	0·09	0·12	0·11	0·11	0·39	...	0·03	...	0·06	0·83	0·33	0·68	0·03	0·13	0·05	0·15

June 1875.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL.
Baric difference. Saugor Island to Port Blair (Mean for month —·161.)	—·090	—·074	—·086	—·131	—·199	—·168	—·123	—·089	—·052	—·099	—·159	—·136	—·169	—·171	—·182	—·191	—·191	—·213	—·233	—·204	—·209	—·272	—·300	—·290	—·211	—·221	—·238	—·328	—·312	—·253	
RAINFALL. Burdwan ...	0·10	0·01	...	...	0·25	0·23	0·08	0·39	0·19	...	0·33	1·14	2·17	0·23	0·07	0·24	0·32	0·27	0·19	0·32	0·19	0·61	1·80	0·51	0·05	0·05	0·38	0·69	0·14	0·22	12·06
Presidency	0·13	0·10	0·01	0·09	0·20	0·16	0·32	0·58	0·13	0·32	1·69	2·19	1·39	0·07	0·09	0·71	0·35	0·37	0·26	0·57	0·35	0·66	1·14	0·59	0·16	0·24	0·38	0·56	0·36	0·17	14·04
Dacca ...	0·29	0·22	0·26	0·07	0·65	1·07	0·54	0·76	0·64	1·06	1·17	2·13	2·76	0·15	0·12	1·05	0·19	0·34	0·39	0·48	0·14	0·35	0·56	1·24	0·41	0·20	0·20	0·16	0·84	0·37	20·91
Chittagong	0·27	0·07	0·06	0·28	0·43	2·53	0·50	0·12	1·43	1·64	0·80	1·34	3·27	0·93	0·61	0·24	0·18	0·32	1·00	0·71	0·15	0·48	0·46	2·31	1·91	0·44	0·10	0·94	1·30	1·10	20·75

July 1875.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL.
Baric difference. Saugor Island to Port Blair (Mean for month—·178.)	—·202	·212	—·220	—·211	—·150	—·093	—·035	—·059	—·110	—·150	—·165	—·216	—·329	—·317	—·307	—·161	—·101	—·121	—·213	—·305	—·268	—·231	—·250	—·286	—·302	—·215	—·177	—·221	—·218	—·169	—·222	
RAINFALL. Burdwan	0·17	0·34	0·12	0·56	0·91	0·50	0·07	0·07	0·11	0·04	0·47	0·10	0·76	0·67	0·87	0·00	0·06	0·03	0·61	0·34	0·17	0·24	0·12	0·06	0·20	0·31	0·20	0·44	0·38	0·18	0·46	9·91
Presidency	0·19	0·20	0·25	0·36	0·82	0·16	0·15	0·03	0·02	0·09	0·67	0·98	1·18	0·60	0·86	0·15	0·01	0·16	0·21	0·12	0·19	0·13	0·12	0·11	0·20	0·19	0·63	0·23	0·31	0·31	0·71	10·64
Dacca ...	0·16	0·09	0·19	0·30	0·61	0·21	0·09	0·02	0·05	0·50	0·89	1·68	0·29	0·13	0·33	0·03	0·20	0·51	0·19	0·14	0·56	0·18	0·22	0·02	0·17	0·16	0·89	1·03	2·21	0·66	1·78	15·66
Chittagong	0·61	0·68	0·75	0·29	0·49	0·10	0·03	0·51	0·05	0·59	2·01	2·17	1·15	0·63	0·28	0·01	0·11	0·39	0·48	0·30	0·01	0·19	0·14	0·09	0·27	1·06	1·15	1·50	2·74	2·63	5·16	26·57

August 1875.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL.
Baric difference. Saugor Island to Port Blair (Mean for month—·133).	—·181	—·170	—·182	—·116	—·110	—·111	—·113	—·111	—·009	—·026	—·093	—·111	—·105	—·173	—·211	—·163	—·156	—·169	—·131	—·118	—·117	—·131	—·153	—·156	—·067	—·054	—·002	+·010	—·023	—·035	—·069	
RAINFALL. Burdwan	0·60	1·29	1·25	0·30	0·72	0·60	0·33	0·24	0·16	0·31	0·06	0·03	0·09	0·23	0·50	0·37	0·10	0·09	0·20	0·10	0·27	0·34	0·21	1·13	1·24	0·39	0·14	0·21	0·10	0·15	0·04	12·14
Presidency	1·13	1·14	0·92	0·37	0·52	0·57	0·29	0·15	0·22	0·15	0·05	0·11	0·02	0·41	0·37	0·25	0·17	0·10	0·23	0·20	0·21	0·31	0·81	1·10	0·69	0·20	0·10	0·39	0·21	0·30	0·09	12·53
Dacca ...	2·70	2·14	1·37	0·62	0·54	0·26	0·14	0·28	0·11	0·09	0·07	0·17	0·11	0·15	0·29	0·28	0·15	0·09	0·10	0·15	0·11	0·59	0·68	0·90	0·62	0·36	0·21	0·35	0·01	0·05	0·19	14·15
Chittagong	4·08	3·30	2·07	1·4	0·39	0·21	0·15	0·09	0·03	0·02	...	0·38	0·37	0·81	0·1	0·15	0·31	0·12	0·25	0·11	0·03	0·77	0·70	1·79	3·50	0·91	0·15	0·44	0·14	0·10	0·50	21·27

September 1875.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	TOTAL.
Baric difference. Saugor Island to Port Blair (Mean for month—·074.)	—·014	—·018	—·120	—·163	—·151	—·138	—·193	—·252	—·238	—·106	—·051	—·041	—·010	—·053	—·041	—·035	—·010	+·012	+·027	+·007	+·027	—·009	—·016	—·012	—·020	—·021	—·050	—·001	—·013	—·036	
RAINFALL. Burdwan	0·02	0·20	0·09	0·37	0·00	0·18	0·33	0·19	0·85	0·21	0·04	0·12	0·04	0·16	0·23	0·28	0·31	0·47	0·24	0·05	0·26	...	0·05	0·75	0·24	0·15	0·24	0·38	0·19	...	7·38
Presidency	0·11	0·18	0·05	0·30	1·07	0·20	0·14	0·20	0·50	0·70	0·01	0·03	0·04	0·24	0·22	0·12	0·31	0·26	0·13	0·00	0·12	0·01	0·08	0·52	0·15	0·21	0·12	0·22	0·29	0·15	7·14
Dacca ...	0·27	0·14	0·24	1·03	0·87	0·16	0·20	0·19	0·57	0·53	...	0·12	0·15	0·17	0·33	0·14	0·30	0·06	...	0·01	0·18	0·22	0·02	0·43	0·07	0·16	0·66	0·11	0·25	0·04	8·21
Chittagong	0·06	0·03	0·60	0·86	0·61	0·07	0·15	0·82	0·90	0·19	0·04	0·13	0·33	0·48	0·59	...	...	...	...	0·17	0·16	0·18	0·66	...	0·15	0·03	0·14	0·15	0·25	0·15	9·10

October 1875.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL.
Baric difference. Saugor Island to Port Blair (Mean for month+·039.)	—·024	—·001	+·001	+·031	+·021	—·003	—·017	+·022	+·019	+·050	+·078	+·050	+·073	+·073	+·081	+·072	+·112	+·118	+·090	+·115	+·120	+·051	+·082	+·070	+·073	+·077	+·080	+·056	+·060	+·104	+·123	
RAINFALL. Burdwan	...	0·01	...	0·01	0·12	...	...	...	...	...	...	...	...	...	0·02	1·17	0·32	0·31	0·04	0·01	...	0·05	0·17	0·04	...	...	...	...	...	...	...	2·57
Presidency	0·14	0·01	...	0·02	0·08	0·01	...	...	...	...	...	...	...	...	0·09	0·09	0·10	0·04	0·03	0·11	0·03	0·04	0·21	0·05	...	...	...	...	...	...	...	1·98
Dacca ...	...	...	...	...	0·20	0·35	0·00	...	...	...	...	...	...	0·08	0·29	0·13	0·03	0·10	0·07	0·01	...	0·06	0·17	0·06	...	0·01	...	...	...	...	...	1·69
Chittagong	0·20	...	0·19	0·03	0·05	0·11	0·10	0·05	...	0·03	...	...	...	...	0·03	0·01	0·37	0·01	0·05	0·07	...	...	0·04	0·05	0·10	0·05	...	...	...	...	...	1·97

Our knowledge of the distribution and variation of atmospheric pressure in the Bay is very imperfect. Assuming, however, that the pressures at Port Blair and Saugor Island indicate roughly and generally the relation between the pressure of the mid-Bay and the coast of Bengal, the preceding tables seem to establish the following general conclusions—

1st.—That, during the rains, the baric differences between the mid-Bay and the Bengal coast are in a state of continuous oscillation, indicating an action between the Bay and the land, oscillatory, and not constant and continuous in its character.

2nd.—That an increase of the baric difference, above the normal amount, is accompanied or followed by the advance of a saturated current from the Bay to the coast.

3rd.—That this saturated current is determined, first of all, generally to the north-east, giving the heaviest rainfall to the Arakan coast, advancing from Akyab northwards, and gradually extending northwards and westwards over Bengal.

4th.—That the effect of this indraught from the Bay and the condensation of its moisture over Bengal is an increase of pressure in Bengal, and (usually) a slight decrease in the mid-Bay. The baric differences consequently diminish, and after a time, this change is followed by a partial or entire cessation of the heavy rainfall.

To return to the consideration of the storm of June 17th: the next fact, which the observations given in Table III illustrate, is the distribution of pressure at the time of the storm.

During the period from June 13th to June 16th, the decrease of atmospheric pressure was—

At Cuttack	·085
„ False Point	·087
„ Saugor Island	·109
„ Calcutta	·099
„ Jessore	·076
„ Dacca	·081
„ Akyab	·060
„ Chittagong	·052
„ Madras	·023

Similarly, from the 17th to the 21st, the fall was—

At Cuttack	·036
„ False Point	·073
„ Saugor Island	·120
„ Calcutta (from the 17th to the 20th)	·111
„ Jessore	·125
„ Dacca	·107
„ Akyab	·029
„ Chittagong	·026

These figures, consequently, show that the area, including Saugor Island, Calcutta, Dacca, and Jessore, was the seat of very considerable barometric oscillations, accompanying

a disturbed state of the atmospheric condition. The readings, reduced to sea-level, indicate that the same area was an area of relatively low pressure, with reference to the whole of the Bay of Bengal, Assam, Orissa, and Bengal. The following are the readings reduced to sea-level for the period June 13th to 17th :—

	13th.	14th.	15th.	16th.	17th.
Port Blair	29·810	29·841	29·820	29·837	29·852
Madras	·730	·751	·747	·753	·783
Akyab	·765	·761	·749	·705	·725
False Point	·680	·659	·625	·593	·621
Saugor Island	·670	·641	·591	·561	·612
Calcutta	·650	·614	·565	·551	·593
Jessore	·634	·612	·537	·559	·609
Dacca	·680	·641	·596	·600	·635
Burdwan	·623	·591	·533	·537	·602
Goalpara	·631	·585	·577	·609	·614

Hence, whilst one of the usual features of the rainy season was gradually developing from the 13th to the 17th—*viz.*, a diminution of pressure in Bengal, and more especially in the western half of it, and over the north-west corner of the Bay, relatively to the middle of the Bay—there was also an area of relatively low pressure in Bengal itself, which included Dacca, Jessore, Calcutta, and Saugor Island.

The increase of the baric gradient from the 13th, between the mid-Bay of Bengal and Bengal, determined a current of moisture across the Bay in the normal direction, namely, from the south-west. This is evident from the commencement of the rains at Akyab on the 14th and 15th. At Saugor Island, Calcutta, Jessore, and Dacca, the rains appear to have begun on the 17th, having been ushered in by the storm of the 17th, one effect of which was the apparent reversal of the afternoon barometric oscillation under consideration. The commencement of the rains, although it indicates, and was consequent on, the disturbed state of the atmosphere, and the increased baric difference between Bengal and the Bay, more especially during the formation and continuance of the area of low pressure of the 13th to 17th, does not explain or account for the peculiar features of the introductory storm of the 17th.

The almost instantaneous and complete change of wind direction and the great fall of temperature, before the commencement of the rainfall, show that it was not merely an inrush of a strong moisture current from the Bay. The sudden chilling of the atmosphere, accompanied, as it was, by an increase of pressure, also proves that it was probably not due to the internal action of a mass of air, during the condensation, either of the air itself or of the aqueous vapour contained in it, or to horizontal or surface currents from the interior, which would necessarily have been warm currents. The only possible explanation seems to be that the changes were produced by the downrush of a cold upper current, and that this current was the return current from Bengal towards the Bay, which, as Mr. Blanford, in his "Winds of Northern India," states, maintains the equilibrium of the atmospheric distribution in Northern India at this period. The existence of this return current is indicated by the upper cloud movements over Bengal. The increased relative pressure over the middle of the Bay, on this supposition, produced, first of all, a strong moisture-current of considerable depth from the south-west, in the normal direction towards the shores of the

Arakan coast. This probably checked the flow of the upper northerly return current; and before the influx due to the diminished relative pressure had set in towards Bengal, partly as a direct current and partly by deflexion of the moisture-current from the Arakan coast, the centre of the area of depression was visited by a downrush of the upper north-east current in a more or less slanting direction. The consequences of such a downrush would apparently be such as actually occurred, *viz.*, an increased pressure for a time, a sudden and great diminution of temperature and of the tension of aqueous vapour, and a reversal of wind direction. As an example of the descent of a cold current of air, and its immediate effects on the meteorological elements of observation, it is very instructive. The rainfall was first of all due to the action of the cool current partially intermixing with the more humid lower current; but afterwards it was probably produced by the condensation of the moisture-currents from the Bay moving to the region of relatively low pressure.

From recent investigations, it would appear that a descending current of air in all, except, perhaps, the most unusual combination of circumstances, would be raised in temperature, very considerably above the neighbouring strata, by the process of compression during descent, from the action of the circumjacent atmospheric strata. Physical calculations show that the transfer of a mass of dry air vertically upwards or downwards through a height of 183 feet, accompanied with the expansion or compression necessary to maintain equilibrium during the process of ascent or descent, produces a diminution or elevation of temperature of 1° F. The observed decrease of temperature with height is much less than this, averaging 300 feet per degree Fahrenheit. If we suppose that the heat developed by the action of compression, in the transfer of a mass of air vertically downwards, is entirely expended in increasing the temperature of the mass, it will reach the lowest stratum as a mass of air heated considerably above the previous mass in that stratum, and will therefore be a hot wind. The heat in such cases may be partially radiated into space, or, under exceptional circumstances, may be employed, during the descent of the mass of air, in the evaporation of condensed aqueous vapour. But if these actions be gradual, the arguments adopted by those who employ this method of investigation would seem to prove, that such a mass of air cannot reach the lowest atmospheric strata at a temperature lower than these strata. The sudden descent of a mass of cold air is, however, not an uncommon meteorological phenomenon over the greater part of Northern India.

Mr. S. A. Hill, Meteorological Reporter to the Government of the North-West Provinces, has directed my attention to a local atmospheric disturbance at Allahabad, almost identical, in its meteorological character and phenomena, with the Calcutta storm already discussed. The following account is drawn up mainly from notes furnished by Mr. Hill:—

There was a very extensive atmospheric disturbance in India and the Bay of Bengal from the 5th to the 16th of October. One feature of this was the Vizagapatam cyclone, which was formed in the Bay, on the 5th of October. It travelled slowly across the Bay in a west-north-west direction, striking the coast a few miles north of Vizagapatam, on the morning of the 8th.

The cyclonic disturbance passed onwards, parallel to the coast, along the base of the Eastern Ghâts, on the 8th; and along the eastern edge of the highland of the Chutia Nagpore district on the 9th. On this day, and the 10th, a considerable rainfall occurred

in the eastern half of the North-West Provinces, more especially in the Allahabad, Jaunpor, Azimgarh, Sultanpore, and Purtabgarh districts. 5·26 inches fell, on the 9th, at Allahabad; this being the heaviest recorded rainfall during this period. The disturbed state of the atmosphere continued for some days. On the 13th and 14th severe hail-storms occurred at the sub-Himalayan stations. On the evening of the 14th, the atmospheric disturbance, parallel in its phenomena to the Calcutta storm, occurred at Allahabad.

The following is Mr. Hill's account of it:—

"On the 14th, hourly readings of the barometer and thermometer were taken, from which it appears that, in the morning, the temperature and pressure varied in the normal manner, though the elastic force of vapour was increasing much more rapidly than usual. At 4 P. M. the barometer read somewhat lower than usual. The barometric changes were, however, quite regular up to 4 P. M. The variations of temperature and vapour tension were also fairly regular up to 3 P. M. From 3 P. M. to 4 P. M. the tension of vapour increased from ·704″ to ·840″, the temperature at the time falling somewhat more rapidly than usual. During the next two hours the temperature fell rapidly, and the vapour tension remained nearly constant. At the same time curiously striated clouds began to make their appearance at a considerable height in the atmosphere. They appeared to be coming in quickly from the north-east. At 6 P. M. thunder and lightning began, the surface wind being still easterly. From 6 P. M. to 7 P. M. there was a rise of a degree in temperature, whilst the barometer was rising much faster than its usual rate. About a quarter past seven it commenced to blow violently from the north-west, and at 7-30 P. M. rain began to come down, though not in any considerable quantity. The rain continued until a few moments after 8, at which hour the barometer stood higher than it did at 10 A. M. From 7 to 8 P. M. the temperature fell through 11·2° and the tension of vapour fell to the lowest point it reached during the day. During the fall of the rain, the humidity does not appear to have ever exceeded 91 or 92. The wind commenced to blow from the north-west, but at the end of the storm it had veered round through north to north-east. From 8 to 12 P. M. the pressure fell through ·040″, but there was a slight rise at 11 P. M. The temperature and vapour tension rose again at 11 P. M. to something like their normal amount. The Bareilly observer reports that, during the afternoon, there was a hail-storm with high wind. Some of the hail-stones were very large, and broke the solar radiation thermometer. The *Delhi Gazette* also reports a severe hail-storm at Dehra, somewhat earlier in the day.

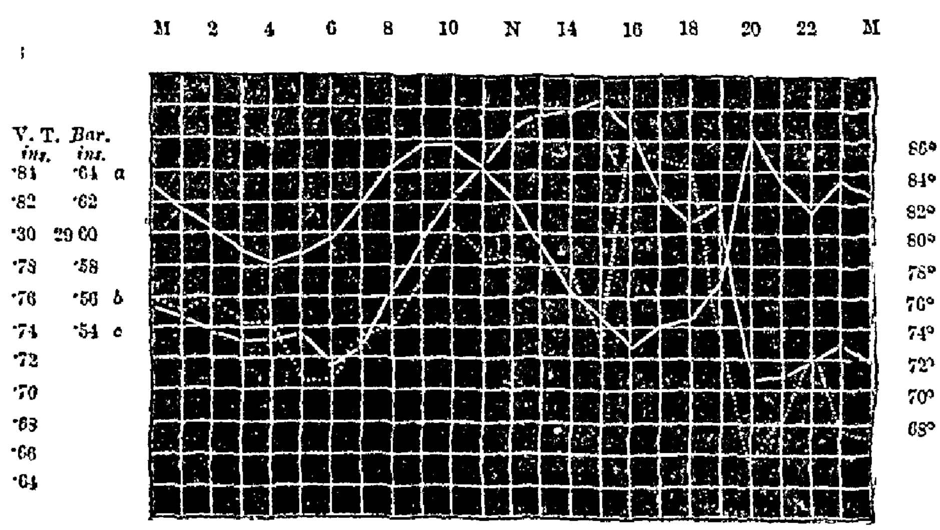
"The barometric curve for Lucknow, on the same day, is quite regular, except that it was very low at 4 P. M. and did not quite recover its normal height at 10 P. M. The winds at Lucknow were southerly up to 5-15 P. M., when a dust-storm from the north and north-east came on; this was succeeded by a slight drizzle from 9 to 10 P. M.; and there was thunder and lightning towards the north, all the evening.

"For three or four days afterwards, there was a tendency to a similar storm in the evening. About 5 P. M. it commenced to get cloudy, and lightning appeared in the north-north-west and north-east. On the 15th, there was a repetition of the phenomena in almost exactly the same order as on the 14th. At 10 A. M. on the 15th, the reduced reading of the barometer was 29·663, at 4 P. M. 29·591, and at 8 P. M. 29·720. At the same time, the temperature fell as it had done the day before, and a few drops of

rain came down. After the 19th, these disturbances entirely ceased. I think we have here clear proof that this atmospheric disturbance was merely local and temporary, and, moreover, that it was in some way connected with the time of the day. In accordance with your suggestion, I have made out the barometric differences between Allahabad and the neighbouring stations. I have no data for several of the stations, to find the abnormal variations; but as the disturbance was a purely temporary one, I think the plan I have adopted will give a fair result. I have calculated the mean difference for the 14th and the four or five preceding days (in most cases including the 15th also), and called these the normal differences. The abnormal variation from this standard on the 14th, especially at 4 P. M., shows clearly, that Allahabad was, that day, a centre of low pressure, and that the pressure in the surrounding regions was highest to the north-west. It is probable that, in the middle of the afternoon, Lucknow was in much the same condition.

"We have not very far to seek for the cause of this low day pressure, especially at Allahabad. During the first ten days of the month there was heavy rain in the Allahabad district, while, all round, the rain was either slight or altogether wanting. The result was rapid evaporation during the hottest hours of the day, as shown by the rapid rise in vapour tension from 3 to 4 P. M., followed after sunset by a still more rapid fall."

The following chart gives graphically the changes which actually occurred:—



a. Pressure. b. Vapour Tension. c. Temperature.

The most important features in the atmospheric changes before and during the storm were—

1st.—A rapid and abnormal rise of pressure between 6 P. M. and 9 P. M. The rise was ·03″ between 6 and 7 P. M. and ·065″ between 8 and 9 P. M.

2nd.—A sudden diminution of the tension of aqueous vapour from 6 to 8 P. M. The decrease between 6 and 7 P. M. was ·107″, and between 7 and 8 P. M. ·098″, giving a total decrease of ·205″ in two hours.

3rd.—A rapid fall of temperature of 11·2° between 7 and 8 P. M., following a slight increase of 1° between 6 and 7 P. M.

4th.—A reversal of wind direction at 7 P. M. from east to north-west.

5th.—A fall of rain, insignificant in amount, commencing at 7-30 P. M. and lasting half an hour. The rainfall was thus subsequent to the above changes, and not a parallel phenomenon in order of time.

The Calcutta and Allahabad storms thus present identical features in the following points—increased pressure, diminished temperature and vapour tension, and reversal of wind direction followed by rainfall. And, as in the case of the Calcutta storm, the observations show clearly, as pointed out by Mr. Hill, that Allahabad and the neighbouring districts formed, on the day of the storm, a region of low pressure relatively to the adjacent districts of Northern India.

The following are the barometric readings of that day, at the observing stations in the North-West Provinces, corrected for temperature :—

Atmospheric pressure.

Month and date.	Allahabad.		Benares.		Bareilly.		Lucknow.		Agra.		Jhansie.		Sutna.		Means of 10 A. M. and 4 P. M. readings						
	10 A. M.	4 P. M.	10 A. M.	4 P. M.	10 A. M.	4 P. M.	10 A. M.	4 P. M.	10 A. M.	4 P. M.	10 A. M.	4 P. M.	10 A. M.	4 P. M.	Allahabad.	Benares.	Bareilly.	Lucknow.	Agra.	Jhansie.	Sutna.
October 11th	29·500	29·517	29 620	29·566	29·294	29 212	29·518	29·441	29 300	29 225	29·042	28 962	28 849	28·766	29·553	29 593	29·252	29·479	29 264	29 002	28·807
" 12th	·660	·570	·663	·588	·389	·272	·512	·513	·381	·278	·100	29 020	·900	·800	·615	·624	·330	·510	·332	·066	·850
" ... 13th	·673	·575	·691	·614	·391	·257	·597	·495	·313	·268	·102	28 993	·911	·803	·624	·652	·324	516	·333	·047	·857
" ... 14th	·635	·509	·679	·574	·316	·292	·560	·416	·327	·251	·064	·998	·880	·769	·572	·626	·304	·496	·291	·031	823
" ... 15th	·663	·592	·685	·632	·408	·328	·556	·546	·420	·324	·067	29 012	·900	·735	·627	·650	...	·551	·354	·039	·818
Mean ...	...	29·553	...	29 595	...	29 258	...	29·485	...	29·271	...	28 998	...	28·775	29·598	29 631	29·302	29·516	2 315	29·037	28·532

The following table, referred to in Mr. Hill's account of the storm, will show that, at 4 P. M., when temperature and vapour tension were falling, Allahabad was the centre of a region of low pressure, extending as far as Lucknow; while at 10 A. M, when the temperature was rising and vapour tension increasing, the pressure at Allahabad, compared with most of the surrounding stations, was high. The normal barometric differences in the table are calculated from the means of the month.

Stations.	Normal Difference.		Difference on the 14th.		Abnormal variation.	
	10 A. M.	4 P. M.	10 A. M.	4 P. M.	10 A. M.	4 P. M
Allahabad to Benares	—·022	—·041	—·044	—·065	—·022	+·024
" Lucknow	+·066	+·06	+·075	+·094	·009	—·031
" Bareilly...	+·279	+·276	+·319	+·218	+·040	+·058
" Agra	+·262	+·256	+·308	+·258	+·046	—·002
" Jhansi...	+·548	+·532	+·571	+·511	+ 023	+·021
" Sutna	+·759	+·760	+·749	+·740	·000	+·020

The changes in the meteorological elements at Allahabad, before and during the storm, and the occurrence of hail-storms to the north-west, appear to indicate clearly, that the immediate cause of the storm was the downrush of a mass of cold air, in a more or less slanting direction, to a region of relatively low pressure at the earth's surface. It appears, therefore, highly probable that, under certain exceptional distributions of pressure at and near the earth's surface, a downrush may occur from a higher stratum to an area of low pressure; and that, when this occurs, it may be accompanied by a rapid and considerable increase of pressure, and diminution of temperature and of the tension of aqueous vapour.

The second case of the apparent reversal of the barometric mid-day oscillation occurred at Chittagong on the 19th of July.

The following table gives the observations at Chittagong and the neighbouring stations for the 18th and 19th July :—

	July.	Barometer.		Mean Barometer.	Temperature.	Wind Direction.		Vapour Tension.	Rainfall.
		10 h.	16 h.			10 h.	16 h.		
Port Blair	18th	29·601	29·721	29·762	81·7	W. S. W.	S. W.	·907	...
	19th	·828	·670	·749	79·5	S. W.	S. W.	·935	0·33
Akyab	18th	·676	·659	·669	74·7	S.	W.	·857	7·12
	19th	·758	·706	·734	80·6	S. W.	S.	1·031	2·47
Chittagong	18th	·473	·455	·465	80·3	S. E.	S. E.	·904	1·21
	19th	·588	·602	·596	78·5	S. E.	N. E.	·888	1·06
Dacca	18th	·486	·395	·449	...	S. E.	S. E.	·976	0·50
	19th	·611	·573	·595	...	S. E.	S. E.	·921	0·69
Jessore	18th	·459	·357	·414	80·4	S. S. E.	S. E.	·971	0·74
	19th	·581	·566	·574	77·4	S. S. E.	S.	·898	2·52
Saugor Island ...	18th	·464	·411	·450	79·2	S. W.	S. W.	·919	1·66
	19th	·561	·535	·533	83·1	S. S. W.	S. S. W.	·976	0·55
Burdwan	18th	·359	·277	·323	80·0	S.	W. S. W.	·959	0·72
	19th	·467	·415	·414	81·2	S.	S. S. E.	·942	0·51
False Point	18th	·493	·431	·473	82·4	S. W.	S. W.	·917	0·80
	19th	·574	·530	·560	83·9	S. W.	S. W.	·966	...

The table shows that the actual reversal occurred over a very limited area, which included Chittagong, but did not extend to the neighbouring meteorological stations of Dacca and Akyab. The very small amount of the mid-day oscillation at these stations, however, confirms the fact of the actual reversal observed at Chittagong.

The first prominent feature in the meteorology of the period July 13th to 21st was the excessive rainfall which occurred over the whole north-east coast of the Bay of Bengal and the adjacent districts of Bengal. Table VII gives the rainfall at each of the revenue stations recording rainfall, in the Dacca, Chittagong, Jessore, Mymensing, and Backergunge districts. It will be observed that the heaviest rainfall occurred on the 17th and 18th in the Akyab and adjacent districts, and on the 19th and 20th in the Chittagong, Backergunge, and Dacca districts; and that the rainfall of the 19th was exceptionally heavy over the whole of the Jessore, Dacca, and Backergunge districts, and at Noakhally to the west of Chittagong.

TABLE VII.

		15th.	16th.	17th.	18th.	19th.	20th.	21st.	TOTAL.
JESSORE	Jessore	0·15	1·20	0·94	0·74	2·52	0·51	0·06	6·12
	Narail	0·31	0·20	0·98	0·06	2·81	0·73	...	5·09
	Khoolna	0·61	0·98	1·45	0·08	3·95	1·01	0·03	8·11
	Jhenidah	2·07	0·40	0·85	0·65	1·11	0·38	0·10	5·56
	Bagirhat	1·54	1·00	1·26	0·20	3·45	1·68	2·00	11·13
	Magoora	0·40	0·09	1·04	1·72	1·93	0·35	0·08	5·61
DACCA	Dacca	0·90	0·31	0·10	0·10	1·29	1·16	...	3·86
	Moonsheegunge ...	0·45	0·65	0·72	2·06	2·35	...	...	6·23
	Manickgunge ...	0·06	0·09	0·57	1·42	...	0·02	...	2·16
MYMENSINGH ...	Mymensingh... ...	0·11	1·01	0·03	0·75	0·33	0·40	0·02	2·65
	Jamalpur	0·10	...	0·30	0·10	...	0·59	0·35	1·44
	Atia	0·40	0·03	0·06	0·36	0·22	0·04	0·05	1·16
	Kishorgunge... ...	...	0·11	0·09	0·49	0·67	0·24	0·98	2·58
CHITTAGONG ...	Chittagong	2·25	0·72	0·15	1·45	1·20	4·90	...	10·67
	Cox's Bazar... ...	3·07	1·09	5·38	2·96	1·03	0·21	0·93	14·67
NOAKHALLY ...	Noakhally	1·60	0·35	0·91	1·22	9·10	0·30	0·35	13·83
TIPPERAH ...	Comillah	0·18	0·04	0·04	0·14	3·29	1·70	1·06	6·45
	Brahmunberiah ...	...	...	0·03	0·07	1·02	0·62	0·76	2·50
CHITTAGONG HILL TRACTS	Rangamatee... ...	0·32	0·12	0·18	0·85	2·62	1·37	0·22	5·68
HILL TIPPERAH ...	Hill Tipperah ...	0·03	0·05	0·18	0·12	0·70	1·72	0·30	3·10
BACKERGUNGE ...	Burrisaul	0·23	...	0·25	0·23	4·15	0·02	0·59	5·47
	Patooakhally ...	0·43	0·38	1·70	0·70	9·45	0·10	...	12·76
	Dowlatkhan... ...	0·70	0·80	0·90	0·45	7·46	0·40	0·32	11·03
	Perozepore	0·90	...	0·50	0·42	3·60	0·40	0·10	5·92
	Akyab	2·76	2·55	1·75	7·12	2·47	0·21	2·94	19·80

Table VIII gives the mean daily atmospheric pressure, temperature, wind direction, vapour tension, and amount of rainfall at stations along and near the coast of the Bay for the period July 10th to 23rd.

Table VIII.

JULY 1876.

Station	Element	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Port Blair.	Barometer	29·713	29·728	29·707	29·723	29·782	29·774	29·761	29·760	29·762	29·749	29·804	29·701	29·715	29·603
	Temperature	80·5	81·0	81·3	80·0	78·5	78·5	79·5	80·3	81·7	79·5	78·3	79·2	78·8	77·7
	Wind Direction	W. S. W. S. S. W.	S. S. W. S. W.	S. W. W. S. W.	S. S. W. W.	W. S. W. W. S. W.	S. W. W.	S. S. W. S. W.	W. S. W. S. W.	W. S. W. S. W.	S. W. S. W.	W. S. W. W.	W. S. W. W. S. W.	W. S. W. S. W.	W. S. W. W. S. W.
	Vapour Tension	·927	·912	·967	·928	·930	·913	·957	·921	·907	·935	·922	·899	·916	·901
	Rainfall	0·27	0·08	0·13	0·14	1·64	1·02	0·26	0·72	...	0·33	0·90	0·31	0·39	0·70
Madras.	Barometer	29·692	29·694	29·684	29·698	29·718	29·757	29·752	29·725	29·702	29·735	29·769	29·776	29·780	29·696
	Temperature	85·4	85·9	83·0	84·1	83·5	85·4	81·0	82·0	85·8	84·6	84·8	81·2	78·4	83·0
	Wind Direction	W. S. W. S.	S. W. S. W.	S. W. S. W. by S.	S. W. by W. S. W.	W. S. W. S. W.	S. S. W. S. S. W.	S. W. S. by W.	S. S. W. S. W. by S.	W. S. W. S. S. W.	S. W. by W. S.	W. S. W. S. by W	W. by S. S.	S. W. by S. S. by E.	S. W. S. W.
	Vapour Tension	·763	·741	·792	·783	·779	·803	·764	·750	·715	·744	·767	·804	·823	·759
	Rainfall	0·01	0·17	0·04	0·11	0·53	0·05	0·79	...	...	...	0·07	0·10	1·05	0·03
Akyab.	Barometer	29·687	29·710	29·649	29·668	29·712	29·672	29·642	29·629	29·669	29·734	29·742	29·693	29·630	29·561
	Temperature	80·2	76·5	76·9	75·6	78·1	78·2	76·8	76·0	7·17	80·6	81·9	78·4	78·0	77·4
	Wind Direction	S. E. S.	N. N. W. W.	S. W. N.	W. S. W. E.	S. S.	S. E. S.	S. N.	N. S.	S. W.	S. W. S.	S. S. W. S. S. W.	N. N. W. S.	N. N.	S. S.
	Vapour Tension	·909	·876	·946	·860	·898	·964	·900	·913	·857	1·031	1·077	·911	·934	·925
	Rainfall	1·20	2·50	0·78	3·34	2·24	2·78	2·55	1·75	7·12	2·47	0·21	2·94	0·65	0·56
False Point.	Barometer	29·553	29·560	29·533	29·513	29·558	29·502	29·539	29·494	29·473	29·560	29·651	29·609	29·568	29·462
	Temperature	82·6	82·0	83·4	84·4	82·7	82·9	79·4	80·7	82·4	83·9	83·8	83·4	83·5	82·1
	Wind Direction	S. W. S. W.	S. W. S. W.	Calm. S. W.	W. S. W.	Calm. N. W.	W. S. W.	W. W.	S. W. S. W.	S. W. S. W.	S. W. S. W.	S. W. S. W.	S. W. S. W.	W. W.	W. W.
	Vapour Tension	·971	·968	·998	·971	·971	·944	·911	·919	·917	·980	·916	·985	·889	·955
	Rainfall	2·60	0·25	0·20	1·20	0·90	0·30	1·25	1·70	0·80	...	0·31	0·40	...	...
Cuttack.	Barometer	29·451	29·498	29·449	29·474	29·501	29·500	29·475	29·423	29·394	29·486	29·574	29·535	29·513	29·411
	Temperature	84·6	82·3	83·3	82·6	81·2	80·3	79·0	79·4	78·6	81·9	84·1	84·8	82·6	80·9
	Wind Direction	S. W. S. S. W.	S. W. S. S. E.	W. S.	W. S. S. W.	W. S. W. W. S. W.	W. S. W. W. S. W.	W. S. W. S. W.	W. S. W. S. W.	S. S. W. W. S. W.	W. S. W. S. W.	S. W. S. W.	S. W. S. S. W.	S. W. W.	W. W.
	Vapour Tension	·892	·910	·931	·920	·899	·857	·848	·890	·815	·866	·849	·876	·881	·865
	Rainfall	0·26	0·14	...	0·15	0·78	0·13	0·46	0·50	0·70	0·05	0·55	0·40	0·11	0·18
Saugor Island.	Barometer	29·516	29·503	29·530	29·521	29·543	29·524	29·485	29·456	29·450	29·533	29·637	29·610	29·544	29·410
	Temperature	84·2	82·4	83·0	83·2	82·2	82·7	81·3	80·9	79·2	83·1	83·7	84·6	85·5	83·0
	Wind Direction	S. S. W. S. S. W.	S. S. W. S. S. E.	S. E. S.	S. S. E.	W. S. W. S. W.	S. W. S. W.	S. W. W. S. W.	S. W. S. W.	S. W. S. W.	S. S. W. S. S. W.	S. W. S.	S. W. S.	W. S. W. S. W.	S. S. E.
	Vapour Tension	·985	1·013	1·008	1·033	·998	·985	·964	·949	·919	·976	1·007	1·028	1·017	·997
	Rainfall	0·51	0·22	0·33	2·79	1·87	0·59	2·13	0·58	1·60	0·55	0·30	...	...	...
Chittagong.	Barometer	29·558	29·574	29·534	29·512	29·560	29·514	29·485	29·469	29·465	29·590	29·660	29·599	29·551	29·469
	Temperature	81·7	80·3	80·7	80·3	80·3	73·4	79·6	79·7	80·3	78·5	77·8	81·2	81·2	81·2
	Wind Direction	S. E. S. E.	S. S. W.	S. E. S. S. W.	S. S. E. S. S. E.	E. S. S. E.	E. S. E. S. S. E.	S. E. S. S. E.	E. S. S. W.	S. E. S. E.	S. E. N. E.	S. E. S.	S. E. S. W.	S. S. E. S. W.	E. S. W.
	Vapour Tension	·933	·903	·900	·907	·890	·945	·916	·918	·904	·888	·949	·984	·942	·949
	Rainfall	0·01	0·07	0·02	0·20	0·52	1·04	0·21	0·53	1·21	1·06	6·47	0·19	...	...
Calcutta.	Barometer	29·497	29·555	29·518	29·508	29·534	29·518	29·469	29·438	29·429	29·540	29·621	29·582	29·531	29·454
	Temperature	83·9	82·6	84·1	84·2	83·6	81·2	81·3	79·8	78·0	79·0	83·3	83·6	83·7	83·9
	Wind Direction	S. S. W. S. by W.	S. by W. S.	S. E. S.	S. S.	S. S. E. S. S. W.	S. W. S. S. W.	S. S. W. S. W.	S. W. S. W.	S. W. S. W.	S. S. W. S. S. W.	S. S. W. S. S. W.	S. W. S.	W. S. W. S. W.	E. S. E. S. S. E.
	Vapour Tension	1·015	1·015	1·011	1·000	1·023	·987	·981	·956	·893	·946	·975	·995	·997	1·024
	Rainfall	0·10	0·07	0·76	...	...	1·14	0·23	0·20	0·48	2·11	...	1·04	...	0·49
Jessore.	Barometer	29·501	29·543	29·514	29·509	29·525	29·498	29·421	29·421	29·414	29·574	29·619	29·566	29·520	29·453
	Temperature	83·3	82·6	83·2	82·8	82·9	82·0	81·3	80·4	80·4	77·4	81·7	83·8	82·7	84·7
	Wind Direction	S. S. E. S.	S. S.	S. E. S. S. E.	E. S. E.	S. E. S. E.	S. S. W.	S. E. S. E.	S. S. S. E.	S. S. E. S. E.	S. S. E. S.	S. S.	W. S.	S. W. S. S. E.	S. E. S. E.
	Vapour Tension	·961	·978	·994	·992	·973	1·004	·979	·983	·971	·898	1·009	·974	1·035	1·003
	Rainfall	0·02	0·10	0·21	...	0·50	0·15	1·20	0·94	0·74	2·52	0·51	0·06	1·22	...
Dacca.	Barometer	29·542	29·556	29·544	29·521	29·562	29·512	29·476	29·462	29·449	29·595	29·629	29·580	...	29·473
	Temperature	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Wind Direction	S. S. E. S. S. E.	S. S.	S. E. S. S. E	S. E. S. S. E.	S. S. E. S. S. E.	S. S. E. S. E.	E. S. E. E. S. E.	E S. E. S. E.	S. E. S. E.	S. E. S. E.	S. S. E. S.	S. S. W. Calm.	S. S.	E. S. E. S. S. E.
	Vapour Tension	·990	1·015	1·029	·986	·956	·979	·981	1·001	·976	·921	1·000	·975	1·030	1·020
	Rainfall	0·10	0·16	0·10	0·03	0·15	0·69	0·34	0·07	0·50	0·69	1·21	0·03	...	...
Silchar.	Barometer	29·537	29·546	29·533	29·522	29·566	29·539	29·479	29·473	29·474	29·617	29·620	29·578	29·520	29·435
	Temperature	83·7	84·0	82·0	81·9	83·8	83·5	83·4	82·4	81·9	82·6	81·6	80·1	83·1	85·9
	Wind Direction	E. S. W.	N. S. S. W.	W. N. E.	N. W.	E. N. E. N. W.	E. N. W.	N. W. E.	S. E. S. W.	E. E. S. E.	E. W. S. W.	E. N. E. N. W.	E. N. W.	N. E. N. W.	E. N. E. W.
	Vapour Tension	·948	·924	·914	·910	·940	·945	1·003	·957	·971	·905	·955	·922	·931	·984
	Rainfall	1·91	...	0·13	1·39	0·60	0·61	2·56	1·27	0·47	0·25	0·30	0·93	...	0·68

The following comparison will show that, the excessive rainfall, in Bengal, during the period July 15th to 21st, was due to a relative excess of pressure over the mid-Bay, and that this excess induced very strong moisture-currents towards the north-east corner of the Bay. The absolute minimum of pressure was at this time over the Dacca and Jessore districts.

The mean baric difference between Saugor Island and Port Blair, for the month of July, is ·174″, and between Saugor Island and Madras ·155″, the pressure at Saugor Island being throughout the lower.

The daily baric differences for the period July 12th to 23rd were—

				Saugor Island to Port Blair.	Saugor Island to Madras.
12th	...	...	...	·177	·154
13th	...	...	...	·202	·167
14th	...	...	...	·240	·206
15th	...	...	...	·250	·233
16th	...	...	...	·266	·267
17th	...	...	...	·313	·269
18th	...	...	...	·312	·252
19th	...	...	...	·216	·202
20th	...	...	...	·167	·132
21st	...	...	...	·151	·166
22nd	...	...	...	·171	·236
23rd	...	...	...	·253	·256

The baric difference thus increased steadily from the 12th to the 17th, when it was nearly double its normal amount. On the 19th it was much smaller, the change being mainly due to a rapid rise of the barometer in Bengal.

A comparison of the atmospheric pressure at Chittagong and Akyab with that at Port Blair, presents the same features. The normal baric difference, during the month of July, between Akyab and Port Blair is ·044″; and between Chittagong and Port Blair ·170″.

The daily baric differences for the period July 12th to 23rd were—

				Akyab to Port Blair.	Chittagong to Port Blair.
July	12th	...	...	·058	·173
„	13th	...	...	·055	·211
„	14th	...	...	·070	·216
„	15th	...	...	·102	·230
„	16th	...	...	·109	·266
„	17th	...	...	·140	·300
„	18th	...	...	·093	·297
„	19th	...	...	·015	·153
„	20th	...	...	·062	·144
„	21st	...	...	·068	·162
„	22nd	...	...	·085	·164
„	23rd	...	...	·142	·224

The phenomena of heavy rainfall in Lower Bengal, (see pages 127, 128) are also shown in the rainfall of the 16th to the 20th July. The baric difference between Akyab

and Port Blair was greatest on the 17th, when it was more than three times its normal amount for July. On the 17th and 18th very heavy rainfall was experienced at Akyab, the amount for the two days being 12·27 inches. The barometer also rose rapidly from the morning of the 17th, when it was at its lowest. Again, the baric difference between Chittagong, Jessore, Dacca and Saugor Island, and Port Blair, was greatest on the 17th and 18th. *This was followed by an exceptionally heavy and widely extended rainfall* on the 19th, and by a simultaneous rapid increase of atmospheric pressure. It was to this increase of pressure, that the inversion of the mid-day barometric oscillation was apparently due; the amount of the rise, during the period 10 A. M. to 4 P. M. at Chittagong, being absolutely greater than the fall due to the ordinary recurring causes which produce the diurnal oscillation.

The following are a few of the main features of the distribution of the barometric pressure, during the period July 16th to 20th. The readings of the following stations, reduced to sea-level, are—

		16th.	17th.	18th.	19th.	20th.
False Point	...	29·559	29·514	29·493	29·580	29·671
Saugor Island	...	·491	·462	·456	·539	·643
Calcutta	...	·488	·456	·447	·559	·640
Jessore	...	·441	·441	·434	·595	·640
Dacca	...	·511	·497	·484	·630	·664
Akyab	...	·664	·651	·691	·756	·764
Chittagong	...	·577	·561	·557	·688	·752
Madras	...	·775	·748	·724	·757	·791

They show that the pressure was very low in Bengal, and that the minimum of pressure was over Jessore on the 16th, 17th, and 18th. The pressure diminished very slightly during these days, but increased very rapidly on the 19th, the amount of the increase being greatest in the actual region of heavy rainfall of the 19th. Thus, for Jessore, the amount of the increase of atmospheric pressure was ·161″, at Dacca ·146″, and at Chittagong (adjacent to Noakhally, where the heaviest rainfall occurred) it was ·131″; at Saugor Island it was only ·083″ and at Akyab ·065″. The rapid rise of the barometer, which accompanied the heavy rainfall of the 19th, and which was greatest in amount in Jessore and Dacca, did not occur simultaneously with the mid-day fall of the barometer, due to the diurnal oscillation. Hence, at these two stations, although the character of the mid-day oscillation was not altered, the amount (due to the opposing combined causes) was unusually small. At Dacca it was ·038″ and at Jessore ·015″.

There is little that calls for notice in the wind direction or velocity at the various stations during this period, except in so far as they confirm the existence of a strong current from the Bay.

The wind directions, at the coast stations, were nearly parallel to the line of the coast. Thus, at Akyab, they were south-south-west; at Chittagong, south and south-east; at Dacca, east; and at Jessore, east or east-south-east; while at Madras and Cuttack, they were south-south-west or south-west. *The winds at Chittagong, Dacca, and Jessore show* the direct influence of the hills in deflecting the current.

The mean hourly wind velocities for each day, during this period, at the following stations, were—

	14th.	15th.	16th.	17th.	18th.	19th.	20th.
Akyab	4·2	3·7	2·9	3·7	6·0	4·2	2·7
Chittagong	8·1	9·2	9·0	10·7	8·6	9·9	5·7
Dacca	11·1	12·6	8·9	7·7	2·1	3·7	8·5
Jessore	5·9	4·1	4·2	4·5	4·7	5·9	4·5
Saugor Island	9·7	23·0	21·8	27·2	28·9	21·2	14·0

Mean velocity per hour for July.

Akyab	4·0 miles.
Chittagong	7·6 „
Dacca	7·1 „
Jessore	5·3 „
Saugor Island	15·5 „

These figures further establish the fact of the strong atmospheric current from the Bay, during the period, from the 14th to the 18th, of increased baric difference between Bengal and the mid-Bay.

One peculiar feature in connection with the wind deserves record. At Calcutta, the continuous registration of wind by a Beckley's anemometer shows that, on the 19th, until 11-40 A. M., the wind direction varied very slightly, the mean direction being south-south-west. At that time, it veered suddenly round to west-north-west, returning to its normal direction south-south-west at noon. The oscillations of the wind-vane were considerable from that hour until 6 P. M., the wind veering between south and west-south-west. Whether this was due to a slight influx from the region of slightly increased pressure to the west, would probably be very difficult to determine. It, however, seems to indicate this.

The continuous observations, taken by the photographic process, at the Alipore observatory during the year 1877, have already thrown further light upon the meteorological conditions and phenomena of the class of storms known as north-westers in Calcutta, of which the storm already discussed was an example.

During the last week of May and the first three days of June, a succession of these storms occurred. They were all characterised by meteorological features similar to those of the Calcutta storm of June 6th, 1876. The first of this series of north-westers occurred on the 26th of May, the second on the 28th, the third and fourth and fifth on the 30th and 31st of May and the 1st of June, and the sixth and last on the 3rd of June. They all happened at the same time of day, between 6. P. M. and 9 P. M., and lasted for very nearly the same interval. The recurrence of these storms, for a period of a week, is one of many examples of the delicate adjustment of the meteorological conditions, and actions and reactions in tropical countries. It also indicates that they were connected with and partly dependent on diurnal changes, either of pressure, temperature, amount

of aqueous vapour, or wind direction. The whole series of six present identically the same phenomena. These are—

First.—A considerable and rapid rise of the barometer, varying from ·08″ to ·15″.

Second.—A very rapid decrease of temperature, usually amounting to 10° or 12°, the greater part of which always occurred very suddenly, being registered by the thermograph in less than ten minutes.

Third.—An equally rapid and simultaneous decrease in the tension of the aqueous vapour present in the air. This decrease varied from ·15″ to ·2.″

Fourth.—An almost instantaneous reversal of wind direction accompanied by a very considerable increase in its velocity. The wind veers through from twelve to twenty-four points of the compass, and at the end of the storm usually returns to its former direction. The wind velocity in the violent rush which immediately precedes and ushers in the storm proper occasionally amounts to from 40 to 60 miles per hour.

Fifth.—These phenomena are generally followed by a shower of rain, which seldom exceeds in amount half an inch.

The cloud movement which precedes and accompanies the storms is exceedingly complicated, and indicates violent and rapid action and motion in the higher atmospheric strata. Observations on this point are yet much needed, and will probably throw very considerable light on the character of the atmospheric action in the upper strata.

The following notes, taken by Mr. Blanford, of a storm of this class on April 24th, 1868, indicate the character of the cloud movement:—

Hour.	Wind.	Movement of Clouds.
16h.—10 m. ...	S.	
„ 27 m. ...	Variable ...	Overcast. Heavy low masses of cumulo-stratus with edges in cirrus like fibres (apparently attracting each other) passing from South-West to North-East.
„ 35 m. ...	... ...	Lower clouds in patches and ragged; very low, moving from West to South very fast. Upper masses moving more slowly and apparently from South-West to North-East.
„ 37 m. ...	... ...	Clouds higher.
„ 52 m. ...	... ...	Clouds high, ragged patches moving slowly from South-West.
„ 58 m. ...	... ...	Clouds as before, moving from West to East.
17h. ...	... ...	Thin ragged patches of low cloud moving faster from West to East.
„ 2 m. ...	... ...	Low thin ragged masses of cloud moving round.
„ 5 m. ...	... ...	Ditto ditto ditto much thicker.
„ 8 m. ...	... ...	Lower clouds moving North to South in zenith, edges of ditto North-East to South-West.
„ 10 m. ...	... ...	Lower clouds nearly melted away, moving from North-West to South-East.
„ 26 m. ...	... ...	Clouds higher and lighter, moving slowly from North-East to South-West.
„ 40 m. ...	... ...	Cloud forms distinct, sheaf-shaped bundles of cirrus moving from North-West to South-East, or West-North-West to East-South-East, slowly. Height much as before. This seems to be the thickened edge of a mass.
„ 45 m. ...	... ...	Thin folds of clouds, less ragged, still moving from West-North-West to East-South-East.

Facsimile copies of the photographic traces of the barograph and thermograph, taken at Alipore on May 26th and 28th, are given in plate X, to show the rapid changes in the pressure, temperature, &c., during these storms.

The corrections for these instruments have not yet been obtained, as they have only been in use for a short time.* The following tables give the elements of observations as measured from these traces and the trace of a Beckley's anemograph at ten-minute intervals during the storm. They are only, under the circumstances, approximately correct, the error in the case of the barometric readings probably not exceeding ·005" and of the thermometric readings 0·4".

TABLE IX.—*Results of observations taken by the photographic process during a storm, May 26th, 1877.*

Date.	Hour.	Barometer.	Dry bulb.	Wet bulb.	Tension of vapour.	Grains of vapour in cubic foot.	Wind.	
							Direction.	Velocity.
26th of May.	Per mile. 4·0	29·498	91·4	83·3	1·032	10·90	E. N. E.	3 to 4 P. M., 9 miles.
	5·0	·500	91·2	83·6	1·050	11·09	E. N. E.	4 to 5 P. M., 9 miles.
	6·0	·503	90·7	84·3	1·091	11·52	E. N. E.	5 to 6 P. M., 9 miles.
	6·10	·503	90·4	84·5	1·106	11·66	E. N. E.	6 to 6·40 P. M., 5 miles.
	·20	·528	90·0	85·1	1·143	12·05	E. N. E.	
	·30	·547	89·9	84·9	1·134	11·95	E. N. E.	
	·40	·550	89·2	84·3	1·098	11·55	E. N. E.	
	·50	·547	88·5	84·5	1·132	11·91	E. N. E.	6·40 to 7·10 P. M., 8 miles.
	7·0	·547	87·8	84·3	1·131	11·88	E.	7·10 to 8 P. M., 10 miles.
	·10	·535	87·4	83·7	1·107	11·61	E.	
	·20	·590	87·2	83·3	1·088	11·41	E.	
	·30	·635	76·0	74·8	·848	9·21	E.	
	·40	·660	76·0	74·8	·848	9·21	E.	
	·50	·680	76·0	74·7	·844	9·16	7·45 to 8 P.M., sudden change from East through North to N. W.	
	8·0	·700	75·3	73·3	·794	8·61	N. W.	8 to 8·45 P. M., 20 miles (greatest velocity).
	·20	·655	75·3	73·3	·794	8·61	W. N. W.	
	·30	·615	75·3	72·3	·754	8·18	...	
	·40	·625	75·3	72·3	·754	8·18	N. W.	
	9·0	·650	75·0	73·3	·799	8·67	E.	8·45 to 10 P. M., 8 miles.
	·30	·635	75·0	73·3	·799	8·67	E.	
	10·0	·640	75·0	73·5	·799	8·69	S. S. E.	

* The scale of the barogram is about one-third greater than that of the barometer. The horizontal white lines of the thermogram indicate approximately increments of 5° each, but the scales of the two traces of the thermogram are quite independent. The white vertical lines indicate the even hours, 0, 2, 4, &c., each interval representing two hours.

TABLE X.—*Results of observations taken by the self-recording instruments during a storm, May 28th, 1877.*

Date.	Hour.	Barometer.	Hygrometer.		Vapour Tension.	Grains of vapour in cubic foot.	Wind direction.	Wind velocity.
			Dry.	Wet.				
28th May 1877.	4 P. M.	29·625	93·9	82·9	·977	10·19	E.	3 P. M. to 4 P. M., 3½ miles of wind registered.
	5·00	·642	92·0	81·8	·950	9·87	E.	4 to 5 P. M., 5½ miles.
	6·00	·670	89·7	80·8	·931	9·85	E.	5 to 6 P. M., 9 miles.
	·10	·680	89·6	80·6	·923	9·73	E.	6 to 7 P. M., 18½ miles, of which 9 miles were registered from 6·40 P. M. to 6·50 P. M.
	·20	·700	89·0	80·1	·907	9·55	E.	
	·30	·720	83·5	74·1	·717	7·63	E.	
	·40	·725	81·8	74·1	·741	7·84	W. to N.N.W.	
	·50	·700	80·0	71·9	·675	7·25	W. to N.N.W.	
	7·00	·735	79·8	73·0	·727	7·80	N. N. W.	7 to 8 P. M., 10 miles.
	·10	·748	80·0	73·8	·739	7·96	N. N. W. to N. W.	
	·20	·752	79·8	75·3	·818	8·79		
	·30	·770	79·5	74·4	·784	8·41		
	·40	·765	79·3	73·3	·740	7·95		
	·50	·795	79·1	72·6	·715	7·67		
	8·00	·810	78·6	73·3	·750	8·04	W.	8 to 9 P. M., 17½ miles.
	·30	·805	77·1	73·6	·811	8·66	W. S. W.	
	9·00	·780	79·4	73·3	·739	7·93	S. W.	9 to 10 P. M., 19 miles.
	10·00	·750	76·0	73·3	·786	8·54	S.	

The tables derived from the traces of the self-registering instruments, given above, show a remarkable order in the changes of the elements of observation during these storms. They are all preceded by a considerable rise of the barometer; which usually ceases, for a time, with the violent rush of the wind that ushers in the storm proper. The total rise of the barometer varies from ·1″ to ·15″. The first rise is followed by a considerable and almost instantaneous fall of temperature and of the tension of aqueous vapour in the atmosphere. In the storm of the 26th of May, a fall of 11·9″ was registered in ten minutes by the thermograph. As the instruments are situated in a shed closed in by venetians on three sides, the fourth being the wall of the observatory, it takes some little time before the air inside and the thermometer acquire the temperature of the external air. It is therefore probable that the change of temperature is almost instantaneous, and must therefore be due to the inrush of a mass of cold air, which either drives on or tilts up the air it is displacing. This sudden decrease in the temperature and in the amount of vapour present in the air is, in the few cases I have as yet had the opportunity of examining, followed, very shortly afterwards, by an almost instantaneous change

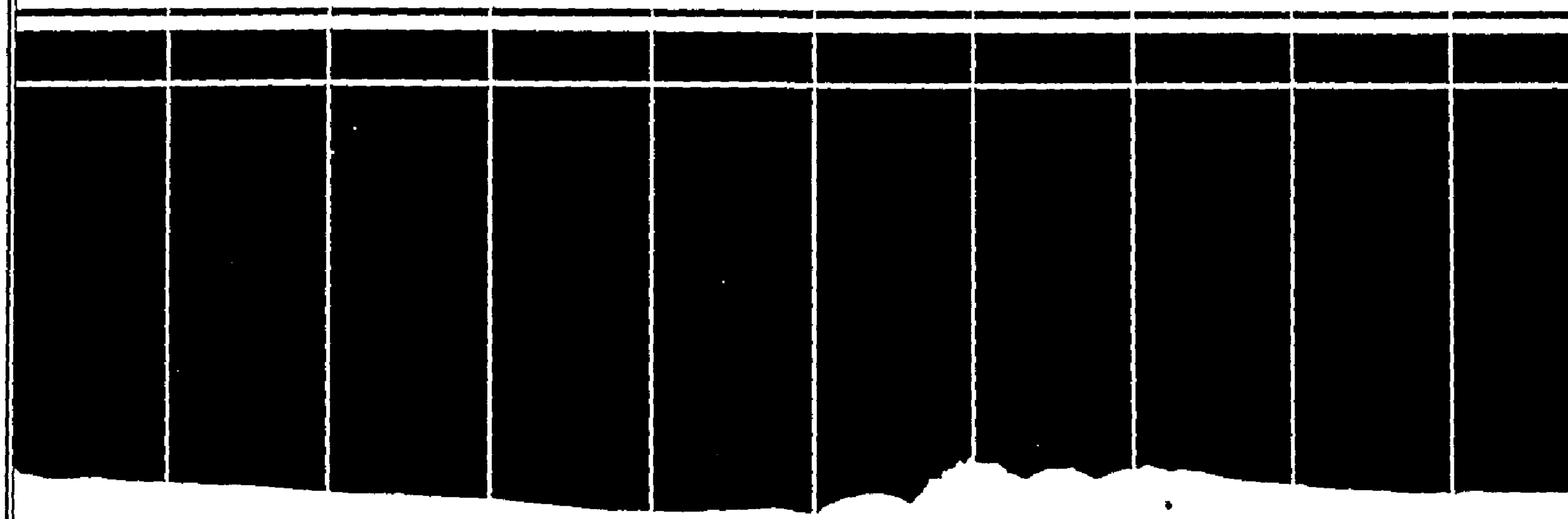
of wind direction and by a sudden increase of wind velocity. This is the commencement of the storm, proper. During the storm, the wind blows in gusts of several minutes, separated by brief intervals, during which it is much less violent. In all cases, the barometer begins to fall with the commencement of the violent wind; and its oscillations, so far as can yet be judged, seem to depend chiefly, if not entirely, upon the changes in the strength of the wind, an increase of velocity accompanying a fall, and a decrease of velocity, a rise of the barometer. This is shown most clearly in the storm of May 28th. The barometer rose until 6·40 P. M., after which it fell ·025″ during the next ten minutes; during which there was a violent rush of wind, in which 11 miles were registered. The barometer rose again until 8·30 P. M., during which interval the wind abated, blowing at the rate of 10 miles per hour. It again increased in violence, blowing from 8-30 P. M. to 10 P. M. at a rate of very nearly 20 miles per hour. The barometer, during this, fell steadily from 29·805 to 29·750. Other north-westers that have been examined, seem to confirm strongly this dependence of the variations of the air pressure upon the wind velocity, during the prevalence of the storm.

The only apparently possible explanation of the phenomena of this class of storms, preceded by the unusual feature of a rise in the barometer, seems to be that already advanced in the discussion of the storm of June 5th, 1876, *viz.*, that, from more or less unknown causes, there is a defect, or a tendency to a defect of pressure in the lower atmospheric strata, over or near the storm region; and that from the relative distribution, of pressure vertically as well as horizontally, in the neighbourhood of the storm region, the motion which ensues towards the region of diminished or diminishing pressure is not solely horizontal, but is due to the descent of a mass of air, from a higher stratum to the surface, in a more or less slanting direction. The increase of pressure, before the actual arrival of the moving mass of air and the commencement of the storm, would on this supposition be due to what is usually termed dynamic pressure, produced by the resistance either of the lower strata in a state of rest or of much slower velocity, or of the earth to the downward motion of the mass descending towards it.

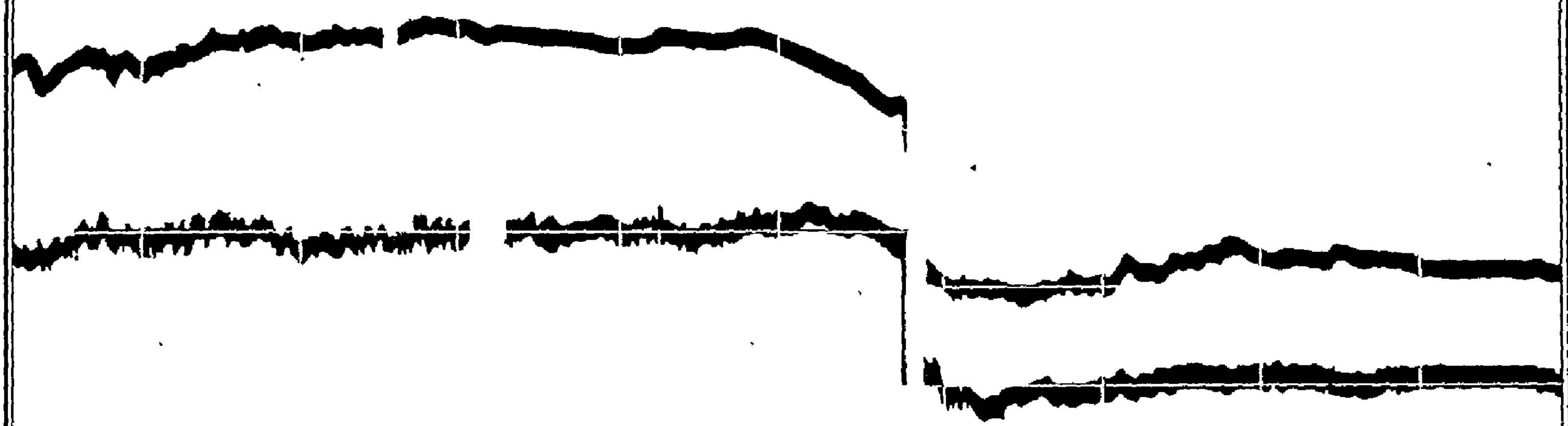
The sudden burst of the storm can only be explained, by assuming that "the atmosphere is a viscous gas," and (to use a recent statement of Sir George Biddell Airy), "it is only on this assumption that cyclonic phenomena and the phenomena of all rotatory storms in the hotter parts of the earth can be explained, and that in such storms there is a mass of hot air which, from the viscosity of its structure, is not able to rise up for a long time, until at last it rises up with a burst." Some of the phenomena of north-westers and of dust-storms in Upper India are apparently only explicable on the assumption of the viscosity of the atmosphere.

The barometer, as has been already stated, rises steadily, until the first onset of the storm, when it falls for some minutes, and afterwards oscillates in such a way as to indicate that the small rapid variations which occur, depend mainly, if not entirely, on the variations in the wind velocity. The fall of the barometer, coincidently with the sudden increase of the wind velocity, is in accordance with the hydro-mechanical principle, that the pressure of a gas under the same conditions of temperature and density diminishes with an increase of its velocity. North-westers in Calcutta occasionally occur at the time

BAROGRAM ON MAY 26TH 1877.



THERMOGRAM ON MAY 26TH 1877.



BAROGRAM ON MAY 28TH 1877.

THERMOGRAM ON MAY 28TH 1877.

of day when the lower surface current changes from the land breeze to the sea breeze. This may be one of the causes, but it cannot be the main determining cause, as they are exceptional, whilst the change from land to sea breezes is of daily occurrence at certain seasons of the year. The observations, taken up to the present time, are not sufficient in number to establish the inference, that the primary causes are what have been indicated in the preceding discussion on the Calcutta storm of June 6th, 1874, and the Allahabad storm of October 1876—a deficiency of pressure over a land region, accompanied with a greater deviation from a state of relative equilibrium of pressure in a vertical than in a horizontal direction.

V.—*On the rainfall of Benares, considered in relation to the prevailing winds.* By

S. A. Hill, B. Sc., *Meteorological Reporter to the Government of the North-Western Provinces and Oudh.*

The relations of rain-frequency and probability to wind-direction, pointed out by Mr. H. F. Blanford in his paper on the winds of Calcutta, published in the first part of these *Memoirs*,* are so very curious and so unlike what might be expected *à priori*, that I have been led to enquire whether any similar relations can be traced at up-country stations. At the suggestion of Mr. Blanford, Benares has been selected as a representative station for the Gangetic plain. For ten years past, meteorological observations have been taken there under the superintendence of the Principal of the College—for the greater part of the time by one of the native professors; and it is believed that the observations are perfectly trustworthy in every point; except that, in the years preceding 1869, the observer neglected to register the calms. This defect, however, will not appreciably alter the resultant directions, deduced by Lambert's formula. For wind observations, the Meteorological Observatory at Benares has the further advantage of being situated on a rising ground, at a considerable distance from trees or high buildings; and the anemometer, since 1874, has been mounted on the top of the College at a height of nearly 80 feet from the ground. Up to some time in the year 1871 or 1872, the instrument was in a much less advantageous position, being merely fixed to the top of a post about 15 feet high; but from that time to 1874, it was placed on the roof of another building in the College compound, in a position not much inferior, as regards exposure, to that which it now occupies. The results, worked out in the following pages, are based on the observations of the ten years, 1867–76. The first point to be considered will be the normal variations of the wind; and in the latter part of the paper, will be given the relations of wind to rainfall.

Part I.—Wind Variations.

(1.) *Daily variation of the wind.*

In the absence of a self-recording anemograph at any of the up-country stations of Northern India, excepting Dehra, where the movement of the wind must be very greatly affected by the physical conformation of the district, it is to be regretted that simple observations of the wind-vane have not been more frequently taken, since the provincial Meteorological Department was first organised in 1863. The hourly observations, commenced, in 1875, at the second-class meteorological stations,

* See *ante*, pp. 20, 22.

will remedy the defect in the course of a few years; but, at present, we are in almost complete ignorance of the movements of the atmosphere during the night. Up to October 1875, the usual observations of temperature and pressure were taken at Benares four times daily,— namely, at 4 A. M., 10 A. M., 4 P. M., and 10 P. M.; but, for some reason or other, the wind direction was never observed at night. The only information regarding the daily variation of the wind, to be obtained from the registers, therefore, is simply a comparison of the direction at 10 A. M. with that at 4 P. M. For the purpose of effecting such a comparison, I have tabulated the 10 A. M. and 4 P. M. observations separately, and calculated the resultant direction and percentage for each month by Lambert's formula. The results, in the form of percentages of all the winds observed during the ten years, are given in the accompanying Tables I and II; and a summary of the original observations will be found in the Appendix Table I.

TABLE I.—*Percentages of winds observed at 10 a. m. during the ten years, 1867–76, tabulated under the eight principal points of the compass, with their resultants calculated by* LAMBERT'S *formula.*

MONTHS.	DIRECTIONS.									RESULTANTS.	
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	Direction.	Percentage.
January	3·2	10·4	16·2	4·6	6·2	10·4	39·3	8·1	1·6	S. 89° W.	25·5
February ...	2·5	6·4	14·8	4·6	3·2	13·4	42·4	11·3	1·4	S. 89° 3′ W.	37·3
March	2·3	4·5	15·2	4·8	9·0	14·2	41·0	5·8	3·2	S. 69° 4′ W.	35·7
April	5·9	5·6	15·4	4·9	5·9	8·7	39·5	11·9	2·1	N. 85° W.	31·4
May	7·7	9·7	28·4	4·5	7·1	6·5	23·2	11·0	1·9	N. 21° E.	8·0
June	5·3	8·7	29·0	6·3	7·7	10·7	24·0	6·3	2·0	S. 44° 4′ E.	5·1
July	3·9	6·4	36·1	6·8	6·4	15·5	21·0	2·6	1·3	S. 45° 3′ E.	16·7
August	1·9	4·5	28·4	5·5	7·4	13·2	30·6	4·9	3·6	S. 33° 2′ W.	14·4
September ...	4·0	10·3	32·0	12·3	7·0	8·7	18·0	5·7	2·0	S. 72° 4′ E.	20·9
October	5·5	7·7	17·7	2·6	6·5	17·4	31·6	7·1	3·9	S. 79° W.	24·3
November ...	8·3	6·3	8·0	3·7	6·3	20·7	35·0	8·7	3·0	S. 84° 3′ W.	40·7
December ...	4·5	5·5	14·2	2·3	8·7	12·6	40·3	9·0	2·9	S. 83° 5′ W.	36·2
YEAR ...	4·6	7·2	21·4	5·2	6·8	12·7	32·1	7·6	2·4	S. 74° 2′ W.	16·9

The resultant directions, given in this table, show the great annual easterly and westerly variation, due to the changes of the monsoons; and they also show that, in every month, except April and May, the resultant is determined by an excess of southerly components, in conjunction with an excess of easterly or westerly ones.

The average values of these meridional components, for each month, are the following, north being indicated by the sign +, and south by the sign —

January.	February.	March.	April.	May.	June.
—0·40	—0·96	—12·93	+2·72	+7·49	—3·75
July.	**August.**	**September.**	**October.**	**November.**	**December.**
—11·93	—12·10	—6·53	—4·62	—4·60	—4·32

The next table (II) shows that the excess of the meridional components of the winds, observed at 4 P. M., is always northerly, except in the months of July and August.

TABLE II.—*Percentage of winds observed at 4 p. m. during the ten years, 1867–76, tabulated under the eight principal points of the compass, with their calculated resultants.*

Months.	Directions.									Resultants.	
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	Direction.	Percentage.
January ...	5·5	9·1	11·4	2·0	1·6	3·9	40·9	21·7	3·9	N. 62° W.	45·4
February ...	6·7	7·8	8·5	1·4	0 3	5·0	52·6	16·3	1·4	N. 70° 1′ W.	55·9
March ...	5·1	6·8	5·5	1·3	2·3	1·9	51·6	22·9	2·6	N. 70° 3′ W.	62·0
April ...	9·1	8·0	3·5	0·3	0·4	1·4	46·5	29·4	1·4	N. 60° W.	67·7
May ...	13·2	13·6	10·3	1·6	1·0	1·6	31·0	26·1	1·6	N. 38° W.	48·1
June ...	9·0	13·3	19·7	5·0	4·0	6·0	24·0	14·7	4·3	N. 19° W.	17·1
July ...	4·2	11 0	25·8	6·8	5·5	12·2	20·3	8·7	5·5	S. 75° E.	3·3
August ...	3·5	9·4	27·1	5·8	5·2	11·9	26·8	7·4	2·9	S. 49° W.	3·5
September ...	4·7	13·7	30·0	9·0	3·7	7·0	17·3	11·3	3·3	N. 65° E.	17·4
October ...	9·0	10·0	12·6	3·9	1·3	2·3	31·3	23·5	6·1	N. 45° W.	33·3
November ...	9·3	6·7	6·3	2·3	1·0	1·7	38·0	25·0	9·7	N. 58° W.	52·2
December ...	5·8	9·4	8·7	1·6	1·0	1·9	49·4	17·4	4·8	N. 65° W.	51·1
YEAR ...	7·1	9·9	14·2	3·4	2·3	4·7	35·7	18·7	4·0	N. 57° W.	34·4

The average values of the north and south components at 4 P. M. are—

January.	February.	March.	April.	May.	June.
+21·57	+18·85	+21·60	+33·56	+38·03	+17·02
July.	**August.**	**September.**	**October.**	**November.**	**December.**
—0·83	—2·30	+7·36	+27·13	+27·89	+21·46

Taking the mean of the whole year, the meridional components are for 10 A. M. — 4·45, and for 4 P. M. +18·69. Comparing these numbers, it appears that the movement from the north is, on the average, always greater, or that from the south always less, at 4 P. M. than at 10 A. M.; and therefore, as a general rule, *the rotation of the wind during the day is direct when the prevailing wind is westerly, and retrograde when it is easterly.* Whether there be any corresponding movement during the night, at Benares, is unknown; but that some such movement takes place is very probable. Thus, at Házáribágh, where wind observations have been taken four times daily, the mean diurnal

components, computed by Lambert's formula, from the number of observed directions, are*—

		Northerly.	Easterly.
4 A. M.	...	—24·02	—31·33
10 A. M.	...	+ 4·00	—31·71
4 P. M.	...	+27·50	—30·12
10 P. M.	...	+ 5·22	—22·18
Mean	...	+ 3·17	—28·83

Expressed as variations from the mean diurnal resultant, at each hour of observation, these become—

		Northerly variation.	Easterly variation.
4 A. M.	...	—27·19	—2·50
10 A. M.	...	+ 0·83	—2·88
4 P. M.	...	+24·33	—1·29
10 P. M.	...	+ 2·05	+6·65

These figures show that, at Házáribágh, the meridional movement between 10 P. M. and 4 A. M. almost exactly compensates that between 10 A. M. and 4 P. M., the difference amounting to only three per cent. of the winds observed. Regarding the cause of this movement, I am unable to make any new suggestion whatever. Like the barometric tides and all other atmospheric phenomena which repeat themselves in the form of diurnal or semi-diurnal oscillations, it is most probably due, in some way, to the action of the sun during the day and radiation into space at night. But to trace the connection between the daily march of the sun from east to west, and this alternating movement of the atmosphere in a north and south direction, is a problem of extreme difficulty. *Primâ facie,* the most plausible explanation, that suggests itself, is this: During the early hours of the day, the temperature over the plains rises rapidly, the heat absorbed by the lower strata of the atmosphere producing a great increase of pressure near the ground; which, by elevating the surfaces of equal pressure over the plains, sets up, in the higher regions of the atmosphere, a steady flow of air towards the Himalayas. This constitutes the well-known southerly or south-westerly day wind, which blows, nearly all the year round, at the hill stations on the outer ridge of the Himalayas. It is probably accompanied, to some extent, by a current in the opposite direction at the surface of the ground, and it is possible that during the night these currents may be reversed in direction. I am not aware, however, that there is any proof of such a reversal, though doubtless the anemograms, taken at the Great Trigonometrical Survey Office at Dehra, will show it if it exists; and the phenomenon under consideration is not confined to stations in the neighbourhood of the hills, or those only removed from them by a hundred miles or so of level ground; but is manifested quite as much at Házáribágh, 250 miles from the hills in a direct line, and 2,010 feet above the sea-level, and at Cuttack on the south side of the hills of Chutia Nagpur and Orissa.

The explanation above proposed appears, therefore, to be quite inapplicable; and we must conclude that this diurnal change of wind direction at Benares is most probably only one manifestation of that general movement of the lower strata of the atmosphere outward from the land which has already been shown to take place at Calcutta and

* From the observations of three years.—H. F. B.

perhaps also at Bombay.* It will perhaps be best to wait for the explanation until we get a fuller knowledge of the movement which actually takes place than can be obtained by simple observations of the wind-vane, to all of which an equal weight is given, irrespectively of the velocity with which the wind is moving.

(2.) *Annual variation of the wind.*

Owing to the absence of night observations, it is impossible to determine, absolutely, the direction of the resultant movement of the wind, during any period, such as a month or a year; but as the day winds almost always blow more strongly than the night winds, it is probable that the direction of the resultant movement of both is not very different from that of the winds which blow during the day. The nearest approach to a correct determination of this resultant, to be obtained from the data given in the appendix, will be got by adding together the 10 A. M. and 4 P. M. observations and treating the sums by Lambert's formula.

Table III contains the percentages of the total number of winds observed under each octant, with the resultant percentage and direction calculated in this way. In the last column I have added a table of the mean daily velocity of the wind as determined by a small Robinson's anemometer, which has been in use only since April 1869.

TABLE III.—*Percentages of winds observed at 10 a. m., and 4 p. m., during the ten years 1867–76, tabulated under the eight principal points of the compass, with their calculated resultants and a table of the mean daily velocities.*

Months.	Directions.									Resultants.		Mean daily velocity in miles.
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	Direction.	Percentage.	
January	4·4	9·7	13·8	3·3	3·9	7·1	40·1	14·9	2·8	N. 72° W.	34·4	67·9
February	4·6	7·1	11·6	3·0	1·8	9·2	47·5	13·8	1·4	N. 79° W.	45·9	79·2
March	3·7	5·6	10·3	3·1	5·6	8·1	46·3	14·4	2·9	N. 85° W.	45·8	101·6
April	7·5	6·8	9·4	2·6	3·2	5·1	43·0	20·6	1·8	N. 68° W.	48·5	104·1
May	10·5	1·16	19·4	3·1	4·0	4·0	27·1	18·5	1·8	N. 30° W.	26·3	111·5
June	7·2	11·0	24·3	5·7	5·8	8·3	24·0	10·5	3·2	N. 10° W.	6·8	111·9
July	4·0	8·7	31·0	6·8	6·0	13·9	20·6	5·6	3·4	S. 49° E.	9·8	103·7
August	2·8	6·9	27·7	5·7	6·3	12·6	28·7	6·1	3·2	S. 37° W.	8·9	92·4
September	4·3	12·0	31·0	10·7	5·3	7·8	17·7	8·5	2·7	N. 89° E.	17·7	80·6
October	7·3	8·9	15·2	3·2	3·9	9·8	31·4	15·3	5·0	N. 66° W.	27·9	53·4
November	8·8	6·5	7·2	3·0	3·7	11·2	36·5	16·8	6·3	N. 75° W.	43·9	44·3
December	5·2	7·4	11·5	1·9	4·8	7·3	44·8	13·2	3·9	N. 78° W.	42·1	52·6
YEAR ...	5·8	8·5	17·8	4·3	4·6	8·7	33·9	13·2	3·2	N. 72° W.	23·7	83·81

The resultants in this table differ very little from those formerly obtained by Mr. Blanford from the observations of six or seven years;† but, in some months, notably in August, the mean direction is very different from that given in the Indian Meteor-

* See *ante*, p. 13.

† See "Winds of Northern India," Phil. Trans., vol. 164, p. 632.

ological Report for the year 1875. In these months, however, the percentage representing the excess in the direction of the resultant is very small; and therefore the resultant directions vary much from year to year. The mean velocity is, in every case, very considerably greater than that given in the "Winds of Northern India;" partly because of the change in the position of the anemometer mentioned above, and perhaps partly also on account of a generally increased velocity in the movement of the atmosphere, corresponding to a rise in the mean temperature since 1870. Köppen, following other writers on the same subject, has shown (Zeitschrift der Oesterrichischen Gesellschaft für Meteorologie, Vol. VIII, No. 17) that the mean temperature of the air is subject to a periodical increase and decrease, the minimum period of one of the cycles falling about the end of the last decade, and the maximum about the middle of the present one, and that the variation is greatest at stations within or near the tropics.

In Plate XI, Figure 1, the resultants for each month are plotted out; a line, drawn from each of the points connected by the thick line, to the centre of the compass, representing the resultant movement, for the corresponding month, in magnitude and direction; subject, of course, to the error due to giving all the observations the same value. The chart shows that, from March to August, the rotation of the winds is direct; while, from August to March, it is retrograde, except perhaps between the middle of December and the middle of January, when there appears to be a slight change in the opposite direction. The resultant movement for the whole year is represented by the line drawn from the point P to the centre of the compass.

TABLE IV.—*Mean monthly variation of the northerly and easterly components of the wind's mean movement, in percentages of the winds observed during the ten years 1867–76.*

Months.	Northerly.		Easterly.	
	Components.	Variation.	Components.	Variation.
January	+ 10·6	+ 3·1	— 32·7	— 10·0
February	+ 8·9	+ 1·4	— 45·0	— 22·3
March	+ 4·3	— 3·2	— 45·7	— 23·0
April	+ 18·2	+ 10·7	— 45·1	— 22·4
May	+ 22·7	+ 15·2	— 13·3	+ 9·4
June	+ 6·6	— 0·9	— 1·2	+ 21·5
July	— 6·4	— 13·9	+ 7·5	+ 30·2
August	— 7·2	— 14·7	— 5·3	+ 17·4
September	+ 0·4	— 7·1	+ 17·8	+ 40·5
October	+ 11·2	+ 3·7	— 25·5	— 2·8
November	+ 11·6	+ 4·1	— 42·4	— 19·7
December	+ 8·6	+ 1·1	— 41·2	— 18·5
MEAN ...	+ 7·5	...	— 22·7	...

In Table IV, are given the components of the resultant wind direction for each month, in the meridional and the east and west directions, together with the variation of each month from the mean of the year. The variations of the two components from month to month are shown graphically in Figures 2 and 3, Pl. XI. In Figures 4, 5, and 6 are given the mean curves of wind velocity, pressure, and temperature, for the sake of comparison.* The most notable feature of both curves for the wind components is,

* The mean pressure and temperature, represented by the horizontal line in each figure, differ slightly from the means for seven years given in the Meteorological Report for 1875, the former being ·005″ lower and the latter 1·4° higher than the values there given, probably owing to the years 1867 and 1868 being hotter than usual.

that they show two maxima and two minima. The meridional variation attains its maximum northerly value in May, and its minimum in August; but there is a secondary minimum in March and a corresponding maximum in November. In like manner, the east and west variation has its greatest positive or easterly value in September, and its greatest negative or westerly value in March; but there is also an easterly maximum in January and a minimum in August. Both components therefore show an oscillation of semi-annual as well as one of annual period, the great oscillation being the change of the monsoons, from north-west to south-east, and *vice versâ*, and the smaller one manifesting itself in the easterly currents which bring the winter rains, and in the prevalence of the south-west over the south-east monsoon in August. If these curves represented actual movements of the wind instead of mere percentages of the observations, some insight into the relations between wind direction and the variations of temperature and pressure might be obtained, by reducing them to mean curves by means of Bessel's formula, and comparing the phases of the successive periodic terms of the formulæ for the wind curves with those of the corresponding terms of the pressure and temperature formulæ. It is evident that the great annual north-west and south-east variation of the wind is the result of the annual variation of pressure, which reaches its minimum at the end of June; but whether there be a secondary variation of the wind corresponding to an oscillation of the barometer of half-yearly period, is a question requiring further data for its elucidation. The co-efficients of the first three periodic terms of Bessel's formula for the annual variation of pressure at Benares are—

$$U' = \cdot 27888 \qquad u' = 102°34'$$
$$U'' = \cdot 01738 \qquad u'' = 241°1'$$
$$U''' = \cdot 01326 \qquad u''' = 216°12'$$

and the mean for the year is 29·529".

Since the angles u', u'', and u''' represent the distances in time of the middle of January from the epoch at which the value of each oscillation is zero, it will be seen that the great oscillation attains its maximum in the first week of January, and its minimum in the first week of July; and that the half-yearly oscillation attains its minima about the 1st of February and the 1st of August, and its maxima about the 1st of May and the 1st of November. It is probable that the wind variation, to some extent, follows both these oscillations of pressure, but curves derived merely from the observed directions, without regard to velocity, do not enable us to trace the connection closely.

The prevalence of the south-west monsoon, during August, over the easterly current from the Bay of Bengal, does not appear to be a phenomenon peculiar to Benares, but, as has been shown by Mr. Blanford in the "Winds of Northern India," [Phil. Trans., vol. 164, p. 571] it is equally well displayed at Agra, Benares, and Patna. The tables accompanying the official report on the Meteorology of India for 1875, also show that there is a similar excess of south-west winds at Házáribágh, and a considerable falling off in the frequency of easterly winds at Patna, Monghyr, and Gya.

The comparative excess of westerly winds in August appears, therefore, to be common to all the stations situated between the middle of the Gangetic Valley and the

ranges of hills to the south, commonly grouped together under the name of the "Vindhya;" and it must be the effect of some general cause, such as the half-yearly oscillation of pressure above referred to.

PART II.—ON THE RELATIONS OF WIND TO RAINFALL.

The object of the present section is to determine, as far as possible, the elements of the hyetic wind-rose as regards frequency of rain, and the absolute quantity which comes from each octant; and also as regards the relative probability of rain with the wind from various quarters. But, inasmuch as the rain at Benares has only been measured and recorded once each day, and the wind direction has been registered only twice, it does not necessarily follow that the rainfall of any particular day came from either of the points recorded as the wind-directions for that day. In the majority of cases, it is quite impossible to obtain from the registers any positive information regarding the quarter from which any particular fall of rain was derived; but in drawing up the tables given below, I have consistently followed a rule, which, I think, will give fairly correct results when the average of a large number of observations is taken, as has been done here. For the greater part of the ten years under discussion, the rain was measured regularly at 10 A. M.; and for this period, the wind direction last recorded—that at 4 P. M. the previous day—has been taken as the mean direction of the rainfall of the 24 hours. If the entry in the wind column for 4 P. M. on the previous day was "calm," then the fall was entered in the column of the table headed "calm." This system, of course, introduces a slight northerly error into all the directions, on account of the wind direction at 4 P. M. being somewhat to the north of its mean direction for the day;* but I have not attempted to correct the error, for want of sufficient data. Besides, during the two years 1875 and 1876, as well as a part of 1874, the rain was measured at 4 P. M.; and each fall, during these years, has been recorded under the wind directions observed at 10 A. M. on the same day, thereby introducing an error in the southerly direction, which tends to counterbalance the other. These tables are given in the Appendix (Table IV).

(1) *Relative frequency of rain.*

In Table V, is given the number of rainy days during the ten years, tabulated under each octant, as described above, together with the relative probability of rain, obtained by dividing the number of rainy days from each octant by the total number of winds observed in that octant, and multiplying the result by 200.† It appears that rain is twice as frequent when the wind is due east as when it blows from any other quarter; and that the next quarter from which rain-bearing winds most frequently blow is due west. After these directions, in order of frequency, come north-east, south-west, north-west, and south-east; and the directions from which rain comes most rarely are the north and south cardinal points.

* See *ante*, page 148.

† In order to get the comparative probability in the form of a percentage, the multiplier 200 has to be used, because the wind direction was noted *twice* each day.

TABLE V.—*Number of rainy days during the ten years, 1867–76, together with the probability of rain when the wind blows from each of the eight principal points of the compass.*

Months.	Rainy days.									Percentage probability of rain.								
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
January	1	2	8	1	...	...	...	3	1	7·40	6·66	18·82	10·00	...	...	...	6·52	11·73
February	...	3	7	3	...	1	1	1	...	...	15·00	21·22	35·30	...	3·84	0·74	2·56	...
March	...	3	2	...	1	1	3	3	...	...	17·14	6·24	...	5·72	4·00	2·10	6·74	...
April	...	...	1	...	...	...	1	2	...	...	...	3·70	...	...	...	0·81	3·40	...
May	2	2	8	...	...	2	1	1	...	6·16	5·56	13·94	...	...	16·00	1·20	1·74	...
June	2	11	16	10	5	8	15	8	6	9·30	33·32	21·92	58·82	28·58	32·00	20·81	25·10	63·15
July	10	18	55	14	9	17	40	12	15	80·00	66·67	57·30	66·66	48·66	89·54	62·50	68·58	142·89
August	6	16	43	12	7	21	28	12	7	70·58	74·42	50·00	68·58	35·90	53·84	31·16	63·16	70·00
September	2	24	45	11	4	10	4	9	6	15·38	66·66	48·38	34·38	25·00	42·56	7·54	35·28	75·00
October	1	6	9	1	1	...	2	3	1	4·44	21·82	19·15	10·00	8·34	...	2·06	6·32	6·44
November	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	...	...	2	1	...	...	...	...	...	...	...	5·62	16·66	...	...	...	...	...
YEAR ...	24	85	196	53	27	60	95	54	36	11·30	27·38	30·32	33·66	16·30	18·92	7·70	11·28	30·50

In Table VI, I have tabulated the rainy days according to three seasons, corresponding to the winter rains, the hot-weather rains, and those of the monsoon. During the ten years under review, there has never been any rain at Benares in the month of November. This break affords the best possible starting-point for the division of the year's rainfall according to seasons. The rains of October always occur in the beginning of the month, and belong to the same season as those of September. The winter rains, accordingly, include those of December, January, and February; the hot-weather rains, those of March, April, and May; and the monsoon rains, those from June to October. The winter rains and the monsoon rains both come chiefly from the east, or a point a few degrees to the north of east; while the rains of March, April, and May contain a larger proportion of westerly and northerly elements, on account of the frequent occurrence of thunder-storms from the north-west in those months.

TABLE VI.—*Total number of rainy days in the ten years 1867–76, tabulated according to seasons.*

Seasons.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
December to February ...	1	5	17	5	0	1	1	4	1
March to May	2	5	11	0	1	3	5	6	...
June to October	21	75	168	48	26	56	89	44	35
Whole Year ...	24	85	196	53	27	60	95	54	36
Do. computed by Bessel's formula ...	27	105	154	84	19	60	97	49	36

There seems to have been a tendency, on the part of the observer, to put down the wind, during the rainy season, as either "easterly" or "westerly," without taking proper care to see whether it was not really more nearly north or south-east, or north or south-west, as the case might be. I have, therefore, calculated the relative probability of rainy winds under each octant, by means of Bessel's formula adapted for eight points, namely:—

$$y = M + U' \sin. (n. 45^\circ + u') + U'' \sin. (n. 90^\circ + u'') +, \&c.$$

extending it as far as the second periodical term only. The co-efficients of these terms have been calculated in the usual way, the numbers given in Table VI having been first of all extended to sixteen points by simple interpolation. The result of the application of the formula has been to decrease considerably the number of winds in the column headed E, and to correspondingly increase those in the north-east and south-east columns, the others being very little changed. The numbers given in the last line of the table are shown graphically in the wind-rose, figure 7, pl. XI. The two directions of maximum frequency are a little to the north of east and a little to the south of west, the absolute maximum being the easterly one; and the two directions of minimum frequency are almost exactly north and south. These directions are determined chiefly by the rainfall of July, August, and September.

(2). *Comparative probability of rain.*

In order to see whether there exists, at Benares, any such dissimilarity between the directions of greatest frequency and greatest probability of rain, as is shown to obtain at Calcutta, in Mr. Blanford's paper above referred to, I have calculated the numbers given above in the second part of Table V. The figures, there given, very nearly represent the percentage probability of rain on any day, when the *mean direction of the wind at 10 A. M. and 4 P. M.* is that shown by the heading of each column. Table VII contains the same elements, tabulated according to the three seasons given above. For each season, the direction of greatest probability of rain is north-east, east, or south-east; and there is a tendency to a secondary maximum about south-west. The numbers in the line for the whole year, are shown graphically in the wind-rose, fig. 8, pl. XI. The form of the curve differs essentially from that obtained for Calcutta, being more like the "frequency" curve of Calcutta than the "probability" one, which it might be expected in some points to resemble. It shows only one distinct maximum and one minimum, and, though the minimum coincides almost exactly with one of the maxima of figure 7, the maximum is less than four points removed from the other direction of greatest frequency.

TABLE VII.—*Comparative probability of rain tabulated according to seasons.*

SEASONS.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
December to February	2·36	6·84	15·32	20·40	...	1·42	0·24	3·18	4·08
March to May	3·05	6·84	9·24	...	2·56	5·78	1·42	3·72	...
June to October	26·92	51·72	42·53	49·23	31·14	34·78	23 70	31·20	65·42
YEAR ...	11·30	27·38	30·32	33·66	16·30	18·92	7·70	11·28	30·90

The evidence of the Benares Registers, such as it is, therefore does not warrant the full application to up-country stations of the local law of rainfall probability at Calcutta. The law, as given at page 20 of Mr. Blanford's paper, is this: *"It is not when the monsoon current is blowing steadily that rain is most probable, but when it is deflected from its normal direction by some local irregularity of pressure, and rain is the more probable in proportion as this deflection is greater."* With the exception of the last clause, I think it may be safely applied to Benares, but there is no evidence of any proportionality there between the deflection of the monsoon current from its normal direction and the probability of rain. If any such connection did exist, the direction from which rain is most probable ought to be about north-north-west, a point not very distant from the actual direction of least probability.

(3.) *Absolute amount of rain from different quarters.*

Table VIII shows the proportion of the total rainfall of the ten years which came from each octant.

TABLE VIII.—*Total rainfall during the ten years, 1867–76, tabulated under the eight principal points of the compass.*

Months.	Total Rainfall.								
	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
January	0·20	0·29	3·96	0·09	...	...	...	0·09	0·05
February	...	0·37	0·45	0·53	...	0·03	0·40	0·08	...
March	...	0·67	0·32	...	0·19	0·20	1·31	0·53	...
April	...	...	0·50	...	...	...	0·60	1·05	...
May	0·11	0·50	3·35	...	...	0·41	0·10	0·05	...
June	0·23	9·35	8·45	7·56	5·35	3·62	11·47	11·08	1·69
July	7·30	9·53	29·60	6·44	5·18	17·87	35·67	9·21	14·26
August	8·29	7·82	23·29	4·90	6·31	12·26	30·88	12·65	6·52
September	0·28	14·87	36·28	8·14	0·58	6·62	2·81	8·78	2·32
October	0·01	3·98	8·21	1·90	0·06	...	0·37	2·68	0·30
November	...	...	...	...	...	...	...	...	...
December	...	...	1·25	0·05	...	...	...	...	...
Year ...	16·42	47·38	115·66	29·61	17·67	41·01	83·61	46·20	25·14

The winter rains of December, January, and February are derived almost entirely from easterly winds; the hot-weather rains of March and April come chiefly with the wind from the west or north-west; and, while, at the beginning and end of the rains,—that is, in May, September, and October,—there is a distinct excess from the east or north-east, the excess during the three rainy months of June, July, and August is from the west or

north-west. The percentage of the total rain which comes from the east in May, September, and October is, however, very high; while the excess from the western side in June, July, and August is inconsiderable, and therefore, on the mean of the whole year, there is a distinct preponderance of rain from the east over that from any other quarter.

In Table IX is given the distribution of the total rainfall of ten years, under each octant, for each of the three seasons into which I have divided the year. The quantity of rain which comes from the west is greater, than the proportion of rainy days, when the wind is in that quarter, would lead one to expect.

TABLE IX.—*Total rainfall of the ten years, 1867–76, tabulated according to seasons.*

Seasons.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
December to February	0·20	0·66	5·66	0·67	...	0·03	0·40	0·17	0·05
March to May	0·11	1·17	4·17	...	0·19	0·61	2·01	1·63	...
June to October	16·11	45·55	105·83	28·94	17·48	40·37	81·20	44·40	25·09
YEAR	16·42	47·38	115·66	29·61	17·67	41·01	83·61	46·20	25·14
Do. computed by Bessel's formula ...	12·14	59·85	97·30	48·41	4·62	45·69	84·74	44·85	25·14

The last horizontal line of the table gives the rainfall of the whole period corrected for errors of observation by Bessel's formula, and the numbers there given have been plotted out in the wind-rose, Figure 9, Pl. XI. The curve in Figure 9 is very similar to that in Figure 7, differing from it only in the greater size of the western side, which means that, on the whole, the rain that accompanies a westerly or north-westerly wind is heavier than that which comes from the east. The average rainfall of 24 hours, when the rain-bearing wind comes from each quarter, may be found by dividing the total amount of rain given in each column of Table IX by the corresponding number of rainy days in Table VI. The quotients are—

N.	N. E.	E.	S. E.	S.	S. W	W.	N. W.
·684	·557	·590	·560	·655	·684	·880	·855

These numbers, when plotted out, form the wind-rose, Figure 10, P. XI. The curve is very irregular, but still it shows a marked preponderance in a direction a little to the north of west. A comparison of this curve with the others, shows that, though the direction of greatest probability of rain does not differ very much from that of greatest frequency, the direction from which the heaviest rain comes is nearly opposite to that of greatest probability. There is, therefore, a well-marked connection between the amount of rain which falls in a day and the deflection of the rain-bearing current from its normal direction. I am unable to advance any good reason for the west being the direction from which the heaviest rain is derived, seeing that westerly or north-westerly winds must traverse a long stretch of considerably elevated country before they reach Benares, full allowance being made for the change of direction produced by the rotation of the earth. It is most probable, I think, that the westerly character of these rainy winds is purely local, being due to some local area of barometric depression, towards which the winds curve round in a spiral manner, and then ascending, discharging the greater part of their vapour in the form of heavy rain.

APPENDIX.

TABLE I.—*Number of winds observed at 10 a. m. and 4 p. m. from 1867 to 1876.*

JANUARY.

Year.	10-hours.									16-hours.								
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
1867 ...	...	4	8	...	...	...	19	...	...	...	3	5	1	...	...	22	...	...
1868 ...	2	4	3	3	1	5	7	6	...	1	6	3	2	1	2	4	12	...
1869 ...	2	3	7	3	1	3	9	2	1	6	2	1	...	...	...	14	5	3
1870 ...	1	3	3	...	6	...	15	2	1	1	2	2	...	1	2	8	12	3
1871 ...	1	4	3	...	...	3	15	5	...	1	2	3	...	...	...	10	13	2
1872 ...	1	4	12	1	1	1	9	2	...	2	8	7	...	...	...	7	5	2
1873 ...	...	2	...	2	3	10	9	4	1	2	...	1	...	1	2	16	7	2
1874 ...	...	2	5	3	3	2	12	...	2	...	3	5	1	2	4	14	...	...
1875 ...	1	2	6	2	4	7	5	4	...	3	1	3	2	...	2	9	11	...
1876 ...	2	4	3	...	...	1	21	...	...	1	1	5	...	...	...	22	2	...
Total ...	10	32	50	14	19	32	121	25	5	17	28	35	6	5	12	126	67	12
Percentage	3·2	10·4	16·2	4·6	6·2	10·4	39·3	8·1	1·6	5·5	9·1	11·4	2·0	1·6	3·9	40·9	21·7	3·9
Mean direction...	S. 89° W. Percentage 25·5.									N. 62° W. Percentage 45·4.								

FEBRUARY.

Year.	10-hours.									16-hours.								
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
1867 ...	...	...	8	...	...	...	20	...	...	...	...	7	...	...	...	21	...	...
1868 ...	1	...	2	4	...	4	15	3	...	...	3	1	...	...	5	16	4	...
1869 ...	2	3	4	...	...	4	10	5	...	2	2	1	...	...	1	12	8	2
1870 ...	...	1	12	2	...	2	11	...	...	5	2	6	...	...	...	12	2	1
1871 ...	...	3	6	1	1	2	8	6	1	2	4	2	1	...	1	8	9	1
1872 ...	...	6	3	2	1	3	8	6	...	5	6	2	1	1	...	7	7	...
1873 ...	1	1	...	...	2	7	12	5	...	1	...	...	...	...	3	17	7	...
1874 ...	...	2	4	2	2	3	12	...	3	2	1	4	1	...	1	19	...	...
1875 ...	1	...	2	2	1	9	6	7	...	2	3	1	1	...	3	11	7	...
1876 ...	2	2	1	...	2	4	18	...	...	...	1	...	...	...	...	26	2	...
Total ...	7	18	42	13	9	38	120	32	4	19	22	24	4	1	14	149	46	4
Percentage	2·5	6·4	14·8	4·6	3·2	13·4	42·4	11·3	1·4	6·7	7·8	8·5	1·4	0·3	5·0	52·6	16·3	1·4
Mean direction...	S. 89° W. Percentage 37·3.									N. 70° W. Percentage 52·8.								

TABLE I—*continued.*

MARCH.

YEARS.	10-HOURS.									16-HOURS.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	13	...	1	...	17	...	...	3	...	9	...	...	...	19	...	...
1868 ...	...	1	7	3	...	3	9	3	5	...	...	1	1	...	2	17	5	5
1869 ...	3	3	7	1	3	3	7	3	1	6	6	1	...	...	1	2	14	1
1870 ...	...	...	4	1	3	7	10	6	...	2	2	1	...	1	1	18	5	1
1871 ...	...	1	5	1	1	3	18	1	1	4	3	1	...	...	...	15	8	...
1872 ...	1	1	2	2	2	5	17	...	1	1	1	...	1	1	...	15	11	1
1873 ...	...	...	1	3	4	5	16	1	1	...	...	...	1	1	...	23	6	...
1874 ...	2	3	3	1	3	10	8	...	1	...	1	3	...	3	1	17	6	...
1875 ...	...	2	5	2	8	4	8	2	...	...	5	...	1	1	1	14	9	...
1876 ...	1	3	...	1	3	4	17	2	...	...	3	1	...	...	...	20	7	...
Total ...	7	14	47	15	28	44	127	18	10	16	21	17	4	7	6	160	71	8
Percentage	2·3	4·5	15·2	4·8	9·0	14·2	41·0	5·8	3·2	5·1	6·8	5·5	1·3	2·3	1·9	51·6	22·9	2·6
Mean direction...	S. 69° W. Percentage 35·7.									N. 70° W. Percentage 62·0.								

APRIL.

YEARS.	10-HOURS.									16-HOURS.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	3	...	1	1	1	4	6	1	1	3	1	1	...	...	...	10	3	...
1868 ...	...	2	5	1	...	2	11	6	3	...	1	...	...	...	1	22	5	1
1869 ...	7	1	3	1	...	3	11	4	...	10	2	...	...	...	...	4	14	...
1870 ...	...	3	8	1	4	1	6	5	2	5	8	3	1	...	...	5	7	1
1871 ...	1	1	12	2	1	1	10	2	...	1	8	3	...	...	...	9	8	1
1872 ...	2	...	2	2	4	3	15	2	...	2	...	...	...	...	1	17	10	...
1873 ...	...	...	1	2	1	5	20	1	...	2	...	...	...	...	...	24	3	1
1874 ...	1	...	6	2	4	2	11	4	...	...	1	...	...	...	...	14	15	...
1875 ...	1	5	5	...	1	1	11	4	...	1	1	3	...	1	1	12	9	...
1876 ...	2	4	1	2	1	3	12	5	...	2	1	...	...	...	1	16	10	...
Total ...	17	16	44	14	17	25	113	34	6	26	23	10	1	1	4	133	84	4
Percentage	5·9	5·6	15·4	4·9	5·9	8·7	39·5	11·9	2·1	9·1	8·0	3·5	0·3	0·4	1·4	46·5	29·4	1·4
Mean direction ...	N. 85° W. Percentage 34·9.									N. 60° W. Percentage 67·7.								

TABLE I—*continued.*

MAY.

YEARS.	10-HOURS.									16-HOURS.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N. E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	2	...	8	...	...	5	11	4	1	...	1	4	...	...	1	12	13	...
1868 ...	4	6	9	1	...	2	4	4	1	6	4	7	...	...	1	5	7	1
1869 ...	1	2	10	1	...	1	8	6	2	8	7	3	...	...	...	3	8	2
1870 ...	4	1	8	1	4	1	6	5	1	7	6	3	...	...	...	10	5	
1871 ...	1	...	23	1	1	...	4	1	...	4	12	6	1	...	2	3	2	1
1872 ...	3	...	3	4	9	1	9	2	...	3	...	...	2	1	...	12	13	.
1873 ...	2	...	3	6	2	2	12	3	1	4	2	2	2	1	...	12	7	1
1874 ...	3	4	1	...	...	3	15	5	...	...	1	...	...	...	..	26	4	...
1875 ...	4	7	13	...	1	4	...	2	...	6	5	6	...	1	1	6	6	...
1876 ...	...	10	10	...	5	1	3	2	...	3	4	1	...	...	...	7	16	...
Total ...	24	30	88	14	22	20	72	34	6	41	42	32	5	3	5	96	81	5
Percentage	7·7	9·7	28·4	4·5	7·1	6·5	23·2	11 0	1·9	13 2	13·6	10·3	1·6	1·0	1·6	31·0	26·1	1·6
Mean direction...	N. 21° E. Percentage 8·0.									N. 38° W. Percentage 48·1.								

JUNE.

YEARS.	10-HOURS.									16-HOURS.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	3	2	13	...	1	2	6	2	1	2	2	12	1	...	1	5	5	2
1868 ...	...	4	7	...	...	2	15	1	1	1	4	7	...	...	6	10	1	1
1869 ...	1	3	12	2	...	2	4	5	1	3	11	6	2	...	...	4	3	1
1870 ...	1	1	5	1	2	4	15	...	1	5	4	4	2	1	1	6	6	1
1871 ...	...	3	16	4	1	2	4	...	...	1	3	12	5	1	2	5	...	1
1872 ...	3	...	3	7	13	1	2	1	...	4	1	5	1	4	2	3	8	2
1873 ...	...	1	3	...	1	7	13	4	1	...	2	2	...	1	2	17	4	2
1874 ...	3	4	10	2	4	4	2	...	1	1	6	5	3	4	2	3	4	2
1875 ...	2	3	11	1	...	2	5	6	...	5	4	5	...	1	1	6	7	1
1876 ...	3	5	7	2	1	6	6	...	...	5	3	1	1	...	1	13	6	0
Total ...	16	26	87	19	23	32	72	19	6	27	40	59	15	12	18	72	41	13
Percentage	5·3	8·7	29·0	6·3	7·7	10·7	24·0	6·3	2·0	9·0	13·3	19·7	5·0	4·0	6·0	24·0	14·7	4·3
Mean direction...	S. 44° E. Percentage 5·1.									N. 10° 2′ W. Percentage 17·1.								

TABLE I—*continued.*

JULY.

Years.	10-hours.									16-hours.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	1	11	...	1	11	6	1	...	1	2	7	...	2	5	12	2	...
1868 ...	2	3	9	...	...	3	14	...	...	2	3	6	1	...	3	9	4	3
1869 ...	2	3	11	1	4	3	4	3	...	2	5	11	4	...	1	2	2	4
1870 ...	...	...	11	3	3	6	6	...	2	...	1	10	2	2	5	5	5	1
1871 ...	1	2	13	2	2	2	7	...	2	1	1	10	1	1	4	5	1	7
1872 ...	...	...	7	8	4	5	5	2	...	2	...	7	6	4	2	8	2	...
1873 ...	1	2	10	1	...	5	12	...	...	1	3	7	...	1	6	10	1	2
1874 ...	...	2	13	4	3	4	5	...	...	1	7	5	4	1	2	5	6	...
1875 ...	3	4	12	...	2	5	3	2	...	2	7	6	1	3	6	5	1	...
1876 ...	3	3	15	2	1	4	3	...	...	1	5	11	2	3	4	2	3	...
Total ...	12	20	112	21	20	48	65	8	4	13	34	80	21	17	38	63	27	17
Percentage	3·9	6·4	36·1	6·8	6·4	15·5	21·0	2·6	1·3	4·2	11·0	25·8	6·8	5·5	12·2	20·3	8·7	5 5
Mean direction...	S. 45° E. Percentage 16·7.									S. 75°1′ E. Percentage 3·3.								

AUGUST.

Years.	10-hours.									16-hours.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	1	...	13	2	2	4	5	1	3	3	...	13	2	2	4	5	1	1
1868 ...	...	2	3	...	...	5	18	...	3	...	3	4	...	...	...	17	6	1
1869 ...	1	1	6	1	...	2	13	6	1	3	5	8	1	1	1	6	3	3
1870 ...	...	2	6	2	6	2	11	...	2	...	4	7	1	1	4	10	3	1
1871 ...	...	...	8	1	5	4	12	1	...	1	3	6	...	1	7	11	...	2
1872 ...	1	...	4	8	6	6	3	1	2	1	1	2	11	6	6	3	...	1
1873 ...	1	...	14	...	...	2	14	...	...	...	2	13	1	...	...	14	1	...
1874 ...	1	1	13	1	1	5	6	3	...	1	4	10	1	2	4	4	5	...
1875 ...	1	5	11	2	1	2	6	3	...	2	4	9	1	1	4	6	4	...
1876 ...	...	3	10	...	2	9	7	...	...	...	3	12	...	2	7	7	...	...
Total ...	6	14	88	17	23	41	95	15	11	11	29	84	18	16	37	83	23	9
Percentage	1·9	4·5	28·4	5·5	7·4	13·2	30·6	4·9	3·6	3·5	9·4	27·1	5·8	5·2	11·9	26·8	7·4	2·9
Mean direction...	S 33°3′ W. Percentage 14·4.									S. 49° W. Percentage 3·5.								

TABLE I—*continued.*

SEPTEMBER.

Years.	10-hours.									16-hours.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	5	3	8	3	3	1	5	1	1	1	1	10	2	1	4	6	4	1
1868 ...	2	4	11	...	3	2	4	3	1	2	6	8	1	...	3	5	3	2
1869 ...	1	4	14	3	2	1	4	1	...	...	8	17	1	1	...	1	2	...
1870 ...	2	4	9	5	...	3	3	2	2	1	9	8	3	2	...	4	1	2
1871 ...	...	1	20	4	2	...	2	...	1	...	2	14	6	1	1	3	2	1
1872 ...	1	...	1	7	4	6	5	5	1	2	...	1	7	2	4	2	8	4
1873 ...	...	1	10	1	3	1	14	...	...	...	2	9	...	2	2	15	...	...
1874 ...	1	1	7	5	2	5	7	2	...	3	3	6	2	1	1	7	7	...
1875 ...	...	8	10	2	1	5	3	1	...	4	8	9	...	...	3	1	5	...
1876 ...	...	5	6	7	1	2	7	2	...	1	2	8	5	1	3	8	2	...
Total ...	12	31	96	37	21	26	54	17	6	14	41	90	27	11	21	52	34	10
Percentage	4·0	10·3	32·0	12·3	7·0	8·7	18·0	5·7	2·0	4·7	13·7	30·0	9·0	3·7	7·0	17·3	11·3	3·3
Mean direction...	S. 72°E. Percentage 20·9.									N. 65° E. Percentage 17·4.								

OCTOBER.

Years.	10-hours.									16-hours.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	1	...	7	2	2	5	12	1	1	1	...	6	1	1	...	13	8	1
1868 ...	2	4	4	1	2	5	7	2	4	5	3	4	...	...	...	7	10	2
1869 ...	...	2	9	...	...	1	11	8	...	3	4	7	1	...	1	9	6	...
1870 ...	2	2	12	...	1	5	5	1	3	...	6	9	1	...	...	3	6	6
1871 ...	...	1	7	...	3	3	16	...	1	4	5	1	...	...	1	5	6	9
1872 ...	2	1	1	3	4	8	9	...	3	4	...	2	3	...	2	8	12	...
1873 ...	...	1	2	...	1	5	19	3	...	...	...	2	...	...	1	24	4	...
1874 ...	6	3	7	...	2	5	5	3	...	5	4	4	2	...	...	8	8	...
1875 ...	2	3	4	1	2	6	11	2	...	1	5	3	3	1	2	13	2	1
1876 ...	2	7	2	1	3	11	3	2	...	5	4	1	1	2	...	7	11	...
Total ...	17	24	55	8	20	54	98	22	12	28	31	39	12	4	7	97	73	19
Percentage	5·5	7·7	17·7	2·6	6·5	17·4	31·6	7·1	3·9	9·0	10·0	12·6	3·9	1·3	2·3	31·3	23·5	6·1
Mean direction...	S. 79° W. Percentage 24·3.									N. 45° W. Percentage 38·3.								

TABLE I—*continued.*

NOVEMBER.

Years.	10-hours.									16-hours.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	6	3	...	2	2	6	8	3	...	2	4	...	1	...	2	3	17	1
1868 ...	6	...	...	...	3	4	15	2	...	7	1	2	1	...	...	7	12	...
1869 ...	2	6	4	1	...	1	8	4	4	3	4	4	...	1	...	4	5	9
1870 ...	2	2	...	...	5	1	17	1	2	2	1	...	...	...	...	3	9	15
1871 ...	1	2	6	3	...	2	16	...	...	5	4	...	...	...	...	10	9	2
1872 ...	...	1	6	1	2	10	8	...	2	...	3	6	2	...	2	12	3	2
1873 ...	2	1	7	2	3	4	7	4	...	2	...	7	2	...	...	14	5	...
1874 ...	4	1	1	1	2	8	6	7	...	4	...	...	1	2	...	14	9	...
1875 ...	1	1	...	...	1	11	11	4	1	2	...	...	...	...	...	24	4	...
1876 ...	1	2	...	1	1	15	9	1	...	1	3	...	...	...	1	23	2	...
Total ...	25	19	24	11	19	62	105	26	9	28	20	19	7	3	5	114	75	29
Percentage	8·3	6·3	8·0	3·7	6·3	20·7	35·0	8·7	3·0	9·3	6·7	6·3	2·3	1·0	1·7	38·0	25·0	9·7
Mean direction...	S. 84° W. Percentage 40·7.									N. 58° W. Percentage 44·8.								

DECEMBER.

Years.	10-hours.									16-hours.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	2	...	4	...	...	6	12	5	2	1	6	2	...	...	...	5	15	2
1868 ...	3	3	5	1	1	2	11	4	1	3	4	3	...	...	...	17	2	2
1869 ...	1	...	9	2	2	...	12	2	3	3	4	5	...	...	...	12	4	3
1870 ..	...	2	4	...	3	2	17	3	...	1	3	1	...	...	...	12	12	2
1871 ...	...	7	9	1	3	..	7	1	3	2	4	11	1	...	...	7	3	3
1872 ..	...	...	3	1	...	5	19	3	...	2	...	2	...	...	...	22	3	2
1873 ...	2	1	2	1	5	5	15	...	...	1	4	...	3	1	1	15	5	1
1874 ...	2	1	4	1	7	4	7	5	...	1	1	1	1	1	...	21	5	...
1875 ...	4	2	3	...	1	3	16	2	...	2	3	2	...	1	3	18	2	...
1876 ...	...	1	1	...	5	12	9	3	...	2	...	...	...	...	2	24	3	...
Total ...	14	17	44	7	27	39	125	28	9	18	29	27	5	3	6	153	54	15
Percentage	4·5	5·5	14·2	2·3	8·7	12·6	40·3	9·0	2·9	5·8	9·4	8·7	1·6	1·0	1·9	49·4	17·4	4·8
Mean direction...	S. 83° W. Percentage 36·2.									N. 65° W. Percentage 51·1.								

TABLE II.—*Mean daily velocity of the wind.*

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1869 ...	...	...	...	93·9	115·6	114·1	91·2	64·6	75·6	55·8	28 8	38·3	..
1870 ...	39·4	57·9	70·9	68·9	80·6	97·8	75·9	76·0	52·2	42·0	22·6	32·4	59 7
1871 ...	47·9	51·7	62·8	63·9	73·6	75·4	57·3	68·1	52·0	28·6	30·6	32·5	53·7
1872 ...	38·6	65·2	86·0	77·6	98·0	104·7	116·2	77·3	55·9	37·9	28·9	27·9	67·8
1873 ...	53·6	64·9	86·9	86·5	102·2	94·4	102·7	79·0	99·4	29·1	20·1	65·3	73·7
1874 ...	80·3	51·3	129·4	118·3	134·1	117·7	106·4	102·3	82·0	64·8	51·7	76·2	92·9
1875 ...	77·1	103·0	126·6	169·3	140·3	152·9	137·1	124·4	115·5	90·4	80·8	75·9	116·1
1876 ...	138·6	160·1	148·7	154·9	147·5	138·0	142·7	147·5	112·6	78·9	91·0	72·6	127·7
Mean ...	67·9	79·2	101·6	104·1	111·5	111·9	103·7	92·4	80·6	53·4	44·3	52·6	...

TABLE III.—*Number of rainy days tabulated under eight points of the compass.*

Year.	January.									February.									March.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	3	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
1868 ...	...	1	2	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...
1869 ...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...
1870 ...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...
1871 ...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...
1872 ...	1	1	1	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1873 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...
1874 ...	...	...	...	...	...	...	...	...	...	...	...	1	2	...	...	...	...	...	...	...	1	...	...	...	...	...	...
1875 ...	...	...	1	...	...	...	...	3	...	...	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
1876 ...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...
Total ...	1	2	8	1	...	...	...	3	1	...	3	7	3	...	1	1	1	...	...	3	2	...	1	1	3	3	...

Year.	April.									May.									June.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	...	...	...	...	...	...	...	...	...	4	...	...	...	...	...	...	1	...	3	1	...	2	2	1	2
1868 ...	...	...	...	...	...	...	1	...	...	...	...	2	...	...	...	...	...	...	...	3	...	...	...	2	2	...	1
1869 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	1	...	...
1870 ...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...	2	2	...	...	...	2	...	...
1871 ...	...	...	1	...	...	...	...	1	...	...	1	1	...	...	...	...	...	...	...	...	2	6	1	1	2	...	...
1872 ...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	...	...	...	2	...	1	...	1	2	1
1873 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	1	...	...	...	1	...	...
1874 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	1	3	2	1	2	2	2
1875 ...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	1	2	1	...	1	...	2	3	...
1876 ...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	2	...	...	2	...	...	...
Total ...	...	...	1	...	...	...	1	2	...	2	2	8	...	...	2	1	1	...	2	11	16	10	5	8	15	8	6

TABLE III.—*Number of rainy days tabulated under eight points of the compass*—continued.

Year.	July.									August.									September.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...		...	4	1	...	3	5	...	...	1	...	5	2	1	...	2	...	...	...	1	4	1	1	2	...	1	...
1868 ...	2	...	5	...	...	1	...	1	3	...	1	1	...	...	...	1	3	1	...	...	6	...	...	...	1	2	...
1869 ...	1	3	8	3	...	...	1	1	3	1	2	1	...	...	1	2	...	3	...	4	6	1	...	...	1	2	...
1870 ...	...	...	6	2	2	2	5	2	1	...	1	6	...	...	3	1	2	1	...	2	5	...	1	...	...	...	1
1871 ...	1	1	5	2	...	3	3	1	7	1	2	5	...	...	1	4	1	2	...	2	8	3	...	1	1	...	1
1872 ...	2	...	5	1	3	1	6	1	...	...	1	1	7	3	4	4	...	...	...	...	...	1	1	3	...	1	3
1873 ...	1	1	2	...	1	2	10	1	1	...	2	5	1	...	...	4	...	...	...	2	4	...	...	...	...	...	1
1874 ...	1	6	4	2	1	1	5	4	...	1	2	9	1	2	3	4	4	...	1	3	5	1	...	...	1	2	...
1875 ...	1	5	3	1	2	3	4	1	...	2	4	6	1	1	3	3	2	...	1	5	6	...	...	2	...	...	...
1876 ...	1	3	13	2	...	1	1	...	...	...	1	4	...	...	6	3	...	...	...	5	1	4	1	2	...	1	...
Total ...	10	18	55	14	9	17	40	12	15	6	16	43	12	7	21	28	12	7	2	24	45	11	4	10	4	9	6

Year.	October.									November.									December.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1868 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1869 ...	...	1	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1870 ...	...	2	2	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1871 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...
1872 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1873 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1874 ...	1	1	2	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...
1875 ...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1876 ...	...	2	2	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total ...	1	6	9	1	1	...	2	3	1	...	...	...	...	...	...	...	...	...	...	...	2	1	...	...	...	...	...

TABLE IV.—*Quantity of rain tabulated under eight points of the compass.*

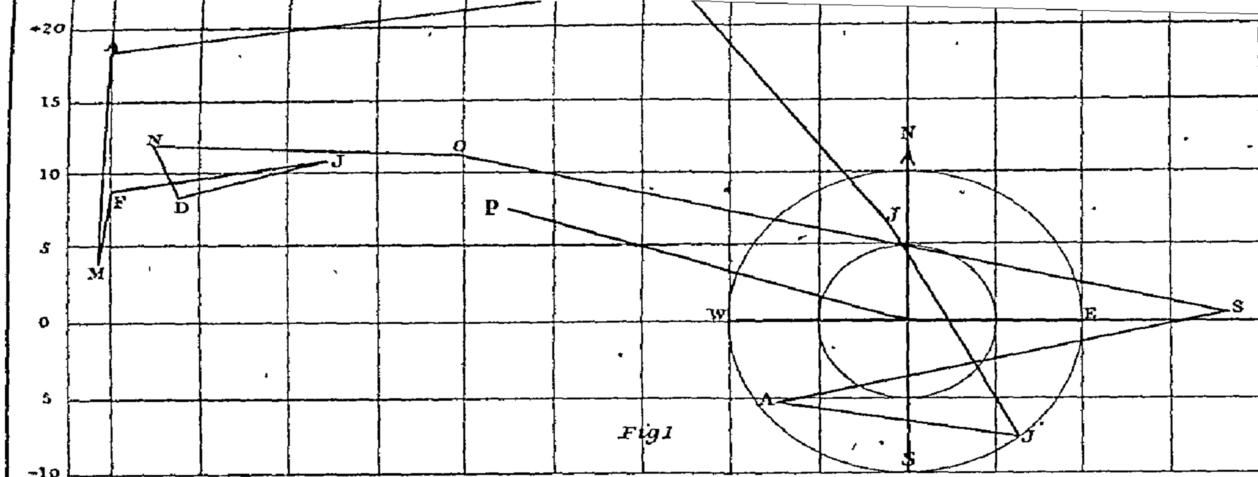
Year.	January.									February.									March.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	1·30	...	...	...	...	...	...	...	...	·14	...	...	...	...	...	...	...	...	...	...	...	...	·90	...	...
1868 ...	...	·19	·41	·09	...	...	...	...	...	...	·15	...	...	...	...	...	...	...	...	...	...	...	...	...	·15	·20	...
1869 ...	...	...	...	...	...	...	...	...	·05	...	...	...	...	...	·03	·40	...	...	...	·30	...	...	...	...	...	...	...
1870 ...	...	...	...	...	...	...	...	...	...	...	...	·17	...	...	...	...	...	...	...	...	...	...	...	·20	·26	...	...
1871 ...	...	...	...	...	...	...	...	...	...	...	·20	...	...	...	...	...	...	...	...	·35	·20	...	...	...	...	...	...
1872 ...	·20	·10	1·35	...	...	...	...	...	...	...	...	·10	·30	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1873 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	·10	...	...	·33	...
1874 ...	...	...	...	...	...	...	...	...	...	...	...	·04	·23	...	...	...	...	...	...	...	·12	...	...	...	...	...	...
1875 ...	...	...	·82	...	...	...	...	·09	...	...	·02	...	...	...	...	...	·08	...	...	...	...	...	...	...	...	...	...
1876 ...	...	...	·05	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	·02	...	...	...	...	...	...	...
Total ...	·20	·29	3·96	·09	...	...	...	·09	·05	...	·37	·45	·53	...	·03	·40	·08	...	...	·67	·32	...	·10	·20	1·31	·53	...

Year.	April.									May.									June.								
	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	...	...	...	...	...	...	...	...	...	2·40	...	...	...	...	...	...	·20	...	2·30	·20	...	·40	·60	1·00	·80
1868 ...	...	...	...	...	...	...	·60	...	...	...	...	·21	...	...	...	...	...	...	...	5·60	...	...	...	1·55	2·75	...	·20
1869 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1·70	...	...	...	1·90	...	...
1870 ...	...	...	...	...	...	...	...	·30	...	·10	...	...	...	...	...	...	...	...	...	1·78	·62	...	...	...	...	1·70	...
1871 ...	...	...	·50	...	...	...	...	·75	...	...	·40	·70	...	...	...	...	...	...	...	...	·85	5·73	·70	·65	·60	...	...
1872 ...	...	...	...	...	...	...	...	...	...	...	·10	...	...	...	...	·10	...	...	...	...	1·20	...	1·50	...	·60	2·65	·50
1873 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	·41	...	...	...	...	...	·20	...	...	...	·12	...	...
1874 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1·49	·35	1·63	·69	·70	4·20	4·32	·19
1875 ...	...	...	...	...	...	...	...	...	...	...	...	·04	...	...	...	...	·05	...	·03	·48	·70	...	2·46	...	·70	1·11	...
1876 ...	...	...	...	...	...	...	...	...	...	·01	...	...	...	...	...	...	...	...	...	...	·53	...	...	·32	...	...	...
Total ...	...	...	·50	...	...	...	·60	1·05	...	·11	·50	3·35	...	...	·41	·10	·05	...	·23	9·35	8·15	7·56	5·35	3·62	11·47	11·08	1·69

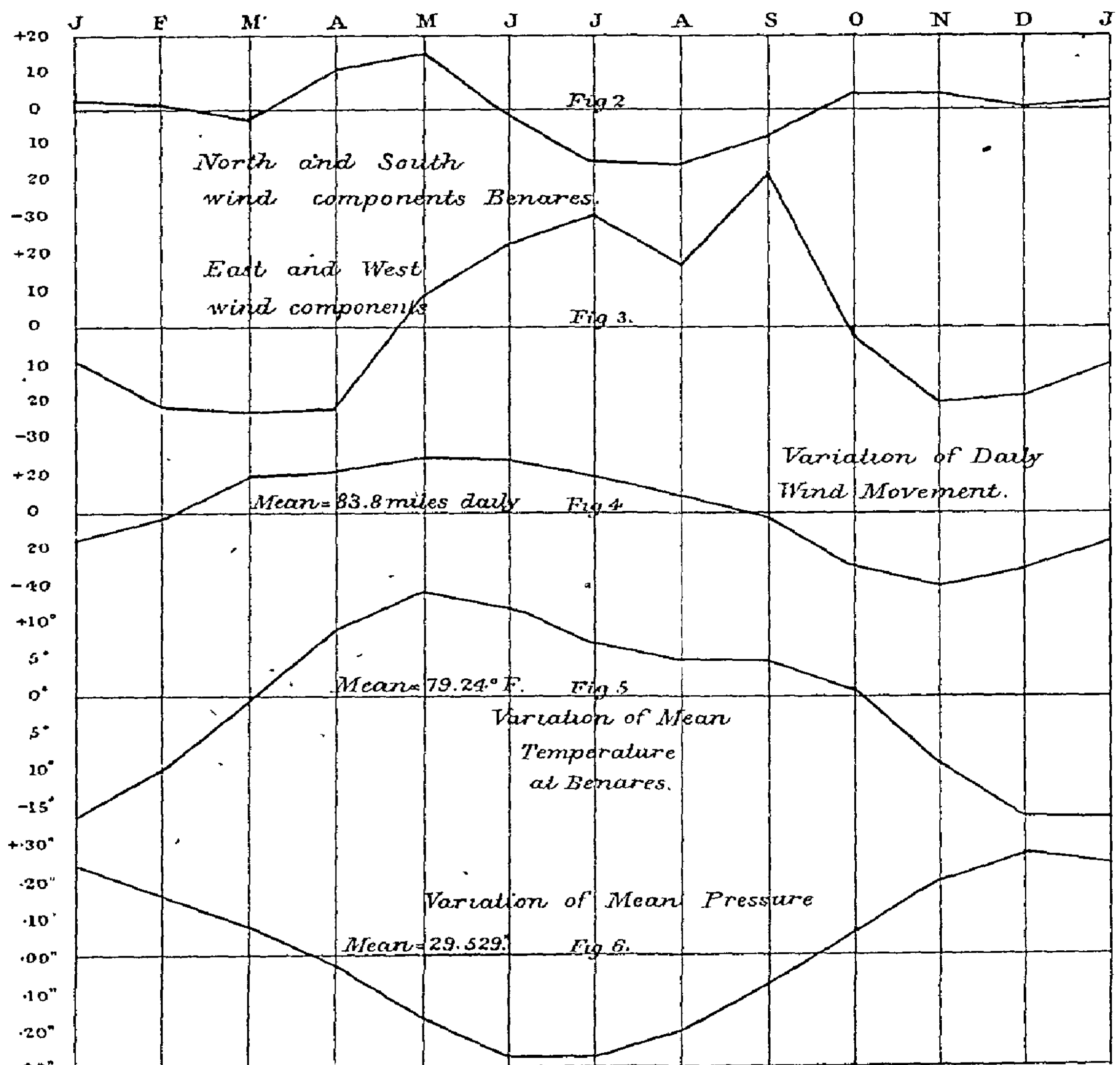
TABLE IV.—*Quantity of rain tabulated under eight points of the compass*—continued.

Year.	July. N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	August. N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	September. N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	2·30	·10	...	4·70	6·50	...	...	·80	...	2·75	1·50	2·00	...	·80	...	...	...	·30	5·95	·70	·40	2·10	...	3·20	...
1868 ...	2·10	...	1·10	...	...	·25	...	1·00	4·30	...	·20	·40	...	...	...	·15	1·00	2·30	...	...	2·25	...	...	...	·10	3·50	...
1869 ...	1·1	1·25	1·25	1·80	...	...	·05	1·10	3·20	·60	1·07	1·00	...	...	·80	·65	...	2·20	...	2·60	4·05	1·90	...	...	·17	1·20	...
1870 ...	...	...	6·67	·70	1·00	3·95	3·15	2·68	·50	...	·90	2·05	...	...	2·60	·25	1·58	·82	...	1·60	5·15	...	·10	...	...	...	·10
1871 ...	·65	·15	2·30	1·25	...	2·05	1·80	·20	6·00	2·80	1·60	3·15	...	...	·90	5·00	·10	1·20	...	·75	9·10	2·25	...	·40	1·50	...	·20
1872 ...	1·60	...	4·60	·20	2·45	·10	3·50	1·25	...	...	·70	·85	2·80	1·35	·70	3·70	...	...	...	...	...	1·00	·05	1·15	...	·05	1·83
1873 ...	·13	·08	1·13	...	·12	1·31	13·83	·06	·26	...	·66	4·81	·21	...	...	5·49	...	...	...	2·85	·92	...	...	...	...	...	·19
1874 ...	·39	1·23	·85	1·86	·47	·27	2·15	1·95	...	·85	·28	2·34	·60	2·94	·45	11·51	8·46	...	·07	1·31	5·60	·08	...	...	1·04	·27	...
1875 ...	·31	2·30	1·00	·12	·54	4·28	3·23	·07	...	3·21	1·57	4·51	·20	·02	3·32	2·07	1·51	...	·21	3·76	2·32	...	...	1·96	...	...	...
1876 ...	1·02	3·62	5·10	·11	...	·43	1·16	...	...	...	·21	·53	...	...	3·49	·66	...	...	...	1·70	·34	2·21	·03	1·01	...	·56	...
Total ...	7·30	9·53	29·00	6·44	5·18	17·87	35·67	9·21	14·26	8·29	7·82	23·20	4·90	6·31	12·26	30·88	12·65	6·52	·28	14·87	36·28	8·14	·58	6·63	2·81	8·78	2·32

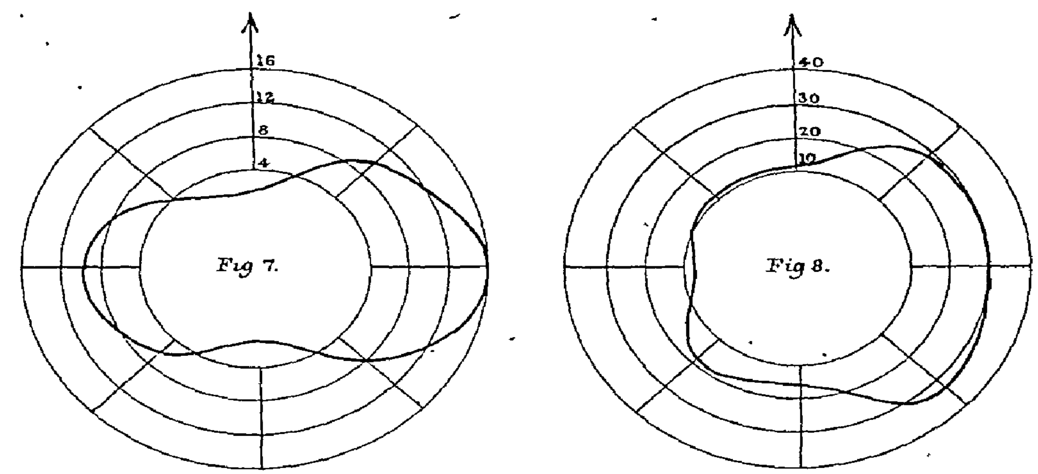
Year.	October. N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	November. N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.	December. N.	N.-E.	E.	S.-E.	S.	S.-W.	W.	N.-W.	Calm.
1867 ...	...	...	...	...	...	...	...	1·70	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1868 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1869 ...	...	·23	2·78	1·90	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1870 ...	...	2·57	2·32	...	...	...	...	...	·30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1871 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1·25	...	...	...	...	...	...
1872 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1873 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1874 ...	·01	·23	2·69	...	...	...	...	·98	...	...	...	...	...	...	...	...	...	...	...	...	...	·05	...	...	...	...	...
1875 ...	...	...	...	...	...	...	·08	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1876 ...	...	·95	·12	...	·06	...	·29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total ...	·01	3·98	8·21	1·90	·06	...	·37	2·68	·30	...	...	...	...	...	...	...	...	...	...	...	1·25	·05	...	...	...	...	...



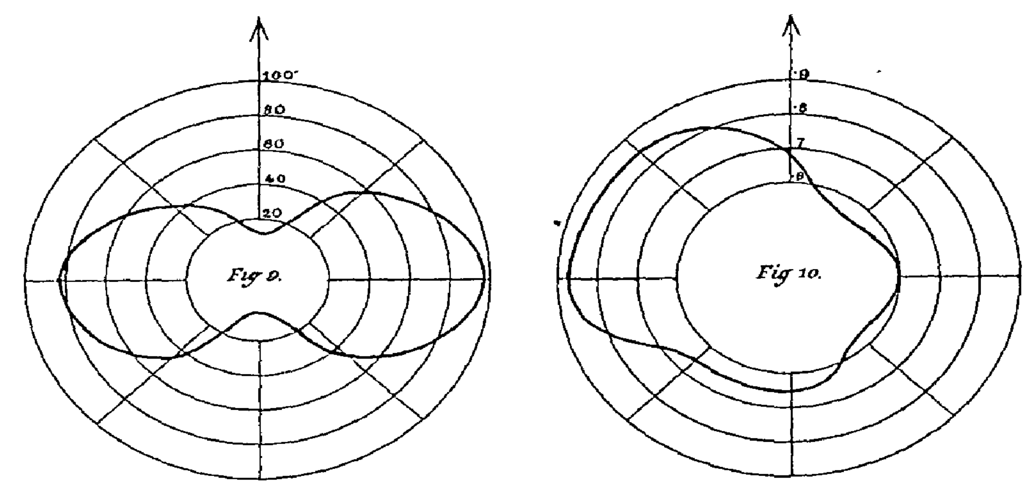
Annual variation of wind-resultants at Benares.



RAINY DAYS.



TOTAL RAIN. RAIN IN 24 HOURS.



VI.—*On the diurnal variation of the Barometer at Indian stations. Part I: Calcutta and Házáribágh.* By HENRY F. BLANFORD, *Meteorological Reporter to the Government of India.*

THE present paper forms the first of a series in which it is proposed to publish the results of the hourly observations recorded at Indian observatories. The double oscillation which the atmospheric pressure undergoes daily, and which is nowhere more prominently exhibited than in India, is a subject that has engaged the attention of many meteorologists, including some who stand in the first rank of physical discoverers; but the physical explanation of the phenomenon remains an unsolved problem. It has long been known that the character of the oscillation undergoes great variations in different parts of the world—variations which affect both the relative and absolute amplitude of the two oscillations, and also the epochs of their critical phases—and some general laws have been pointed out to which these variations conform; but it is only within the last few years that a systematic study of their geographical distribution has been undertaken by Mr. Alexander Buchan, of whose work the first instalment only has as yet reached me.* The quantity of data collected by Mr. Buchan is very large, but not so large as to exclude the necessity of such further additions as India can afford; for in India, not only is the phenomenon exhibited with an intensity and regularity equalled in but few other regions of the earth, but the varied forms under which it presents itself are such as, in a great measure, to epitomize its aspects. In the article *Atmosphere* in the third volume of the 9th edition of the *Encyclopædia Brittanica*, Mr. Buchan has expressly designated India as a country eminently fitted for prosecuting the study of the subject.†

In India itself, the attention of meteorological observers has been directed to the collection of these important data from an early period. According to Humboldt, Bèze noticed the fact of the diurnal oscillation, at Pondicherry, as long ago as 1690; and regular observations of the oscillation were made by Boudier at Chandernagore in 1740. Coming down to recent times, at the three long-established Government observatories of Madras, Bombay, and Calcutta, hourly observations have been recorded daily (night and day) during unbroken periods of 20, 26, and 22 years respectively; and these are among the most complete series for showing the diurnal oscillation that have been furnished for any part of the globe. Other series, less prolonged, are those of Trevandrum, recorded under the superintendence of Mr. J. Broun; the five-year series (two years' bi-hourly and three years' hourly readings) registered at Simla, under Colonel Boileau, in the years 1841 to 1845,‡ and a one-year series at Lucknow.§ Hourly observations have also been

* On the diurnal oscillations of the Barometer, Part I, Trans. Roy. Soc., Edin., Vol. XXII, 1875, page 397.

† "One of the most important steps that could be taken would be an extensive series of observations from such countries as India, which offers such splendid contrasts of climate at all seasons, has a surface covered at one place with the richest vegetation, and at others with vast stretches of sandy deserts, and presents extensive plateaux and sharp ascending peaks—all which conditions are indispensable for collecting the data required for the solution of this vital problem of atmospheric physics."—*Loc. cit.*

‡ See *ante*, page 113; also Boileau's tables.

§ Buist's Manual of Physical Research for India. Part I, p. 105.

recorded on one day of each month at Belgaum, Poona, Deesa, and Kurrachee during the last 20 years; but these have not yet been published, and it is intended that, if found to be trustworthy, they shall appear as part of the present series. The subject of the diurnal variation of pressure, temperature, &c., was taken up systematically by the Meteorological Department of Bengal, in the beginning of 1873; and a certain number of stations were selected, at which hourly observations of all instruments should be recorded, on four days in every month (*viz.*, the 7th, 14th, 21st, and 28th). The system has since been extended to other parts of India, and at the present time it is in operation at the following stations:—

Házaribágh,	since the	7th January	1873.
Patna	,,	7th May	,,
Goálpára	,,	7th July	,,
Sibságar	,,	7th January	1874.
Roorkee	,,	7th March	1875.
Jubbulpore	,,	3rd April	,,
Agra	,,	7th ,,	,,
Pachmarhi	,,	10th May	,,
Nágpur	,,	12th ,,	,,
Allahabad	,,	14th ,,	,,
Lahore	,,	14th July	,,
Lucknow	,,	7th November	,,
Chittagong	,,	7th January	1876.
Cuttack	,,	7th ,,	,,
Rangoon	,,	7th April	,,
Leh	,,	7th August	,,

In addition to these, the four stations, above mentioned, in the Bombay Presidency, continue to furnish one day's hourly observations in each month; and the two observatories of Calcutta and Bombay register the atmospheric pressure, as well as other meteorological elements, continuously by means of autographic instruments.

The present paper gives the results of the hourly observations of pressure at Calcutta and Házaribágh.

CALCUTTA.—Calcutta affords an example of a station in a damp, but not uniformly damp climate, situated on a broad alluvial plain near the sea-level; and 68 miles distant from the sea. The mean relative humidity of the different months varies between 66 and 88 per cent., and the mean vapour tension between ·487 inch in January and ·954 in July. The diurnal range of temperature averages 17·1° in March and 7·8° in August, which are respectively the months of its greatest and least values.

The variation of the winds, both annual and diurnal, has already been described at length in a previous paper, in which a curious coincidence was pointed out between the diurnal changes of the westerly component of the wind-movement and the barometric oscillation. In a communication to the Asiatic Society of Bengal, and another to the *Journal of the Austrian Meteorological Society*, subsequently published, a relation was also pointed out between the land and sea breezes of the coast and the contrasted forms

of the diurnal barometric oscillations at Calcutta and over the head of the Bay of Bengal. Any further notice of this subject may be reserved for the general discussion of the barometric tides, with which it is proposed to conclude the present series of papers.

The present tables are based on 21 years' registers of the observations recorded hourly at the Surveyor General's Office (46, Park Street), in the suburb of Chowringhee, from 1855 to 1875 inclusive. The same instrument has been used throughout. It is a Newman's standard barometer, No. 86, of the form depicted in the *Indian Meteorologist's Vade Mecum*, figure 2. The tube has a diameter of ·514 inch; and, as the result of an indirect comparison, the details of which were published in the XLth volume of the *Journal of the Asiatic Society of Bengal*, the instrument appears to read ·011 higher than the Kew standard, constructed under the superintendence of Professor Balfour Stewart.* No correction for capillarity has been applied to the readings. The cistern of the barometer was 18·11 feet above mean sea-level.

In Table I are given the mean pressure of each hour in each month, deduced directly from the observations, and their differences above or below the mean pressure of the month. Each of the hourly means is the result of nearly 600 readings of the instrument, and each monthly mean that of about 14,400 readings.

From the values in Table I have been computed the rectangular co-ordinates of the constants for the periodical terms of Bessel's formula; and the values so obtained are given in Table II. Each annual series of these rectangular co-ordinates, and also that of the monthly means, has then been corrected by the same formula, in the manner described in Jelinek's *Täglichen Gang der vorzüglichsten Met. Elementen;* and the corrected values are tabulated in Table III. The constants computed from these corrected co-ordinates are given in Table IV; and finally, the pressures corresponding to each hour of Calcutta mean time have been calculated from these data and are shown in Table V. Plate XII represents the curves in the graphic form.

Table VI gives the epochs (to the nearest minute) of maximum and minimum pressure for each semi-diurnal oscillation, in each month of the year. These epochs have been deduced by the method proposed by Professor Jelinek in the work above referred to, *viz.*, by applying the method of differences to the figures in Table IV, and so obtaining a first approximation; which is then corrected to a second approximate value by the formula given in his work. The values of the maximum and minimum pressures, in Table VII, are computed by introducing into the periodical formula the values of Table VI, converted into hour angles. The whole process is described at length in Part I of the *Indian Meteorologist's Vade Mecum*, to which the English reader may be referred for further information on the subject. The whole of these calculations have been worked out by Babu Brojo Mohun Rukhit and Babu Ambica Churn Hazra.

* Unfortunately, owing to a sudden and unforeseen leakage of this instrument, which took place after its removal to the Alipore Observatory, as a consequence of which air gained admission to the tube, it became necessary to insert a new tube. Shortly before the accident, a very careful and prolonged comparison had been made between its readings and those of a precisely similar instrument by the same maker; and as the result of two similar and concordant series of comparative readings with this secondary standard, since the renewal of the tube, it is concluded that, with the new tube, it reads exactly ·007 higher than with the original tube and the same index scale.

TABLE I.—*Mean hourly pressures and hourly variations of pressure at Calcutta. Means of 21 years' daily observations.*

Hours.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Year.	
	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.
	29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +	
0	1·0161	+·0014	·9512	+·0039	·8628	+·0063	·7645	+·0080	·6642	+·0101	·5598	+·0151	·5586	+·0175	·6138	+·0181	·6963	+·0133	·8327	+·0064	·9650	—·0051	1·0271	·0000	·7926	+·0078
1	1·0092	—·0055	·9429	—·0044	·8509	—·0056	·7536	—·0029	·6534	—·0007	·5489	+·0042	·5462	+·0051	·6016	+·0059	·6845	+·0015	·8182	—·0081	·9611	—·0090	1·0205	—·0066	·7826	—·0023
2	1·0011	—·0136	·9331	—·0142	·8394	—·0171	·7421	—·0144	·6423	—·0118	·5386	—·0061	·5364	—·0047	·5906	—·0051	·6743	—·0087	·8097	—·0166	·9526	—·0175	1·0118	—·0153	·7726	—·0123
3	·9926	—·0221	·9234	—·0239	·8305	—·0260	·7340	—·0225	·6361	—·0180	·5305	—·0142	·5258	—·0153	·5805	—·0152	·6649	—·0181	·8024	—·0239	·9461	—·0240	1·0038	—·0233	·7642	—·0206
4	·9894	—·0253	·9187	—·0286	·8277	—·0288	·7348	—·0217	·6384	—·0157	·5277	—·0170	·5246	—·0165	·5773	—·0184	·6619	—·0211	·8029	—·0234	·9454	—·0247	1·0021	—·0250	·7626	—·0222
5	·9970	—·0177	·9302	—·0171	·8418	—·0147	·7500	—·0065	·6515	—·0026	·5367	—·0080	·5301	—·0110	·5844	—·0113	·6705	—·0125	·8148	—·0115	·9590	—·0111	1·0130	—·0141	·7733	—·0115
6	1·0126	—·0021	·9472	—·0001	·8605	+·0040	·7680	+·0115	·6684	+·0143	·5517	+·0070	·5447	+·0036	·5993	+·0036	·6871	+·0041	·8334	+·0071	·9769	+·0068	1·0295	+·0024	·7899	+·0051
7	1·0340	+·0193	·9685	+·0212	·8829	+·0264	·7892	+·0327	·6873	+·0332	·5670	+·0223	·5591	+·0180	·6144	+·0187	·7049	+·0219	·8531	+·0268	·9980	+·0279	1·0510	+·0239	·8091	+·0243
8	1·0630	+·0483	·9950	+·0477	·9116	+·0551	·8114	+·0549	·7040	+·0499	·5795	+·0348	·5720	+·0309	·6298	+·0341	·7248	+·0418	·8755	+·0492	1·0219	+·0518	1·0785	+·0514	·8305	+·0457
9	1·0870	+·0723	1·0180	+·0707	·9289	+·0724	·8250	+·0685	·7126	+·0585	·5867	+·0420	·5788	+·0377	·6394	+·0437	·7362	+·0532	·8877	+·0614	1·0384	+·0683	1·0992	+·0721	·8449	+·0601
10	1·0930	+·0783	1·0268	+·0795	·9325	+·0760	·8258	+·0693	·7117	+·0576	·5861	+·0414	·5801	+·0390	·6410	+·0453	·7365	+·0535	·8867	+·0604	1·0368	+·0667	1·1003	+·0732	·8465	+·0617
11	1·0748	+·0601	1·0140	+·0667	·9213	+·0648	·8146	+·0581	·6999	+·0458	·5785	+·0338	·5731	+·0320	·6324	+·0367	·7255	+·0425	·8693	+·0430	1·0164	+·0463	1·0816	+·0545	·8334	+·0486
12	1·0455	+·0308	·9867	+·0394	·8965	+·0400	·7946	+·0381	·6830	+·0289	·5642	+·0195	·5596	+·0185	·6168	+·0211	·7051	+·0221	·8446	+·0183	·9884	+·0183	1·0500	+·0229	·8113	+·0265
13	1·0115	—·0032	·9537	+·0064	·8659	+·0094	·7657	+·0092	·6595	+·0054	·5450	+·0003	·5416	+·0005	·5966	+·0009	·6785	—·0045	·8160	—·0103	·9562	—·0139	1·0163	—·0108	·7839	—·0009
14	·9851	—·0296	·9232	—·0241	·8343	—·0222	·7361	—·0204	·6326	—·0215	·5247	—·0200	·5209	—·0202	·5732	—·0225	·6523	—·0307	·7911	—·0352	·9336	—·0365	·9919	—·0352	·7583	—·0265
15	·9680	—·0467	·9024	—·0449	·8110	—·0455	·7094	—·0471	·6094	—·0447	·5061	—·0386	·5030	—·0381	·5533	—·0424	·6324	—·0506	·7765	—·0498	·9213	—·0488	·9776	—·0495	·7391	—·0457
16	·9612	—·0535	·8925	—·0548	·7986	—·0579	·6908	—·0657	·5904	—·0637	·4906	—·0541	·4891	—·0520	·5372	—·0585	·6240	—·0590	·7752	—·0511	·9184	—·0517	·9735	—·0536	·7285	—·0563
17	·9660	—·0487	·8933	—·0540	·7959	—·0606	·6869	—·0696	·5885	—·0656	·4900	—·0547	·4885	—·0526	·5370	—·0587	·6270	—·0560	·7817	—·0446	·9272	—·0429	·9807	—·0464	·7300	—·0548
18	·9747	—·0400	·9007	—·0466	·8030	—·0535	·6980	—·0585	·5983	—·0558	·5004	—·0443	·4989	—·0422	·5806	—·0151	·6401	—·0429	·7906	—·0357	·9379	—·0322	·9921	—·0350	·7404	—·0444
19	·9911	—·0236	·9151	—·0322	·8197	—·0368	·7182	—·0383	·6204	—·0337	·5203	—·0244	·5180	—·0231	·5684	—·0273	·6596	—·0234	·8094	—·0169	·9563	—·0138	1·0089	—·0182	·7587	—·0261
20	1·0087	—·0060	·9354	—·0119	·8415	—·0150	·7408	—·0157	·6443	—·0098	·5416	—·0031	·5384	—·0027	·5928	—·0029	·6842	+·0012	·8291	+·0029	·9728	+·0027	1·0248	—·0023	·7796	—·0052
21	1·0214	+·0067	·9507	+·0034	·8605	+·0040	·7629	+·0064	·6622	+·0081	·5586	+·0139	·5577	+·0166	·6135	+·0178	·7030	+·0200	·8418	+·0155	·9833	+·0132	1·0371	+·0100	·7960	+·0113
22	1·0266	+·0119	·9580	+·0107	·8701	+·0136	·7730	+·0165	·6727	+·0186	·5709	+·0262	·5709	+·0298	·6267	+·0310	·7111	+·0281	·8461	+·0198	·9871	+·0170	1·0424	+·0153	·8047	+·0199
23	1·0223	+·0076	·9556	+·0083	·8680	+·0115	·7677	+·0112	·6707	+·0166	·5697	+·0250	·5703	+·0292	·6252	+·0295	·7073	+·0243	·8422	+·0159	·9815	+·0114	1·0369	+·0098	·8015	+·0167
Mean...	1·0147		·9473		·8565		·7565		·6541		·5447		·5411		·5957		·6830		·8263		·9701		1·0271		·7849	

TABLE II.—*Rectangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at Calcutta, computed from Table I.*

MONTHS.	$U'\sin u'$	$U'\cos u'$	$U''\sin u''$	$U''\cos u''$	$U'''\sin u'''$	$U'''\cos u'''$	$U''''\sin u''''$	$U''''\cos u''''$
January	—·01421	+·02492	+·01889	—·03650	—·00037	+·00767	—·00263	—·00195
February	—·01731	+·02686	+·02317	—·03541	—·00052	+·00534	—·00100	—·00166
March	—·01746	+·02957	+·02395	—·03651	+·00047	+·00198	—·00108	—·00072
April	—·01416	+·03319	+·02335	—·03545	—·00124	—·00162	—·00083	+·00087
May	—·00858	+·03140	+·02028	—·03272	—·00123	—·00378	—·00088	+·00152
June	—·00096	+·02177	+·01861	—·02799	—·00033	—·00369	—·00071	+·00108
July	+·00071	+·01924	+·01950	—·02747	—·00027	—·00361	—·00052	+·00043
August	+·00003	+·02185	+·02160	—·03026	—·00080	—·00307	—·00088	+·00045
September	—·00215	+·02310	+·01914	—·03514	—·00108	+·00010	—·00113	—·00005
October	—·00677	+·02243	+·01282	—·03718	+·00090	+·00280	—·00108	—·00121
November	—·00950	+·02309	+·01076	—·03844	+·00049	+·00520	—·00228	—·00139
December	—·01128	+·02454	+·01478	—·03832	+·00049	+·00707	—·00227	—·00193
Mean ...	—·00847	+·02516	+·01890	—·03428	—·00029	+·00120	—·00127	—·00038

TABLE III.—*Values of rectangular co-ordinates from Table II, corrected as annual series.*

MONTHS.	$U'\sin u'$	$U'\cos u'$	$U''\sin u''$	$U''\cos u''$	$U'''\sin u'''$	$U'''\cos u'''$	$U''''\sin u''''$	$U''''\cos u''''$
January	—·01430	+·02519	+·01921	—·03645	—·00042	+·00759	—·00226	—·00202
February	—·01736	+·02674	+·02280	—·03552	—·00029	+·00537	—·00131	—·00165
March	—·01725	+·02954	+·02430	—·03632	+·00013	+·00199	—·00087	—·00068
April	—·01448	+·03340	+·02305	—·03573	—·00091	—·00165	—·00093	+·00079
May	—·00822	+·03102	+·02045	—·03239	—·00147	—·00375	—·00088	+·00161
June	—·00129	+·02219	+·01855	—·02832	—·00027	—·00369	—·00064	+·00101
July	+·00092	+·01885	+·01949	—·02715	—·00013	—·00365	—·00060	+·00045
August	—·00003	+·02215	+·02164	—·03052	—·00111	—·00298	—·00086	+·00048
September	—·00224	+·02301	+·01908	—·03496	—·00066	—·00003	—·00105	—·00013
October	—·00657	+·02233	+·01281	—·03727	+·00049	+·00295	—·00127	—·00109
November	—·00974	+·02330	+·01087	—·03841	+·00081	+·00505	—·00198	—·00152
December	—·01108	+·02424	+·01455	—·03832	+·00034	+·00719	—·00263	—·00183
Year ...	—·00847	+·02516	+·01891	—·03427	—·00029	+·00119	—·00128	—·00038

TABLE IV.—*Constant coefficients of the periodical formula, computed from Tables I and III.*

MONTHS.	Mean.	U'	u'	U''	u''	U'''	u'''	U''''	u''''
	29+								
January	1·0135	·02897	330°25′	·04110	152°38′	·00761	356°48′	·00303	228°19′
February	·9496	·03188	327° 0′	·04232	146°48′	·00538	356°55′	·00211	218°32′
March	·8533	·03421	329°43′	·04370	146°13′	·00199	3°44′	·00110	231°54′
April	·7604	·03640	336°33′	·04252	147°10′	·00189	208°43′	·00122	310°12′
May	·6503	·03209	345°10′	·03831	147°44	·00403	201°26′	·00183	331°11′
June	·5480	·02223	356°41′	·03386	146°46′	·00370	184°10′	·00120	327°50′
July	·5387	·01887	2°48′	·03342	144°20	·00365	182° 0′	·00075	307°10′
August	·5972	·02215	359°55′	·03741	144°40′	·00318	200°26′	·00098	299°11′
September	·6825	·02312	354°27′	·04002	151°25′	·00067	267° 4′	·00106	262°47′
October	·8262	·02327	343°36′	·03933	160°58′	·00299	9°21′	·00168	229°18′
November	·9705	·02525	337°19′	·03992	164°22′	·00511	9° 8′	·00250	232°27′
December	1·0274	·02665	335°26′	·04107	158°55′	·00720	2°44′	·00320	235°15′
Year ...	·7848	·02655	341°24′	·03914	151° 7′	·00123	346° 9′	·00134	253°42′

TABLE I.—*Mean hourly pressures and hourly variations of pressure at Calcutta. Means of 21 years' daily observations.*

Hours.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Year.	
	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.
	29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +		29 +	
0	1·0161	+·0014	·9512	+·0039	·8628	+·0063	·7645	+·0080	·6642	+·0101	·5598	+·0151	·5586	+·0175	·6138	+·0181	·6963	+·0133	·8327	+·0064	·9650	—·0051	1·0271	·0000	·7926	+·0078
1	1·0092	—·0055	·9429	—·0044	·8509	—·0056	·7536	—·0029	·6534	—·0007	·5459	+·0012	·5462	+·0051	·6016	+·0059	·6845	+·0015	·8182	—·0081	·9611	—·0090	1·0205	—·0066	·7826	—·0022
2	1·0011	—·0136	·9331	—·0142	·8394	—·0171	·7421	—·0144	·6423	—·0118	·5386	—·0061	·5364	—·0047	·5906	—·0051	·6743	—·0087	·8097	—·0166	·9526	—·0175	1·0118	—·0153	·7726	—·0122
3	·9926	—·0221	·9234	—·0239	·8305	—·0260	·7340	—·0225	·6361	—·0180	·5305	—·0142	·5258	—·0153	·5805	—·0152	·6649	—·0181	·8024	—·0239	·9461	—·0240	1·0038	—·0233	·7642	—·0206
4	·9894	—·0253	·9187	—·0286	·8277	—·0288	·7348	—·0217	·6384	—·0157	·5277	—·0170	·5246	—·0165	·5773	—·0184	·6619	—·0211	·8029	—·0234	·9454	—·0247	1·0021	—·0250	·7626	—·0222
5	·9970	—·0177	·9302	—·0171	·8418	—·0147	·7500	—·0065	·6515	—·0026	·5357	—·0090	·5301	—·0110	·5844	—·0113	·6705	—·0125	·8148	—·0115	·9590	—·0111	1·0130	—·0141	·7733	—·0115
6	1·0126	—·0021	·9472	—·0001	·8605	+·0040	·7680	+·0115	·6684	+·0143	·5517	+·0070	·5447	+·0036	·5993	+·0036	·6871	+·0041	·8334	+·0071	·9769	+·0068	1·0295	+·0024	·7899	+·0051
7	1·0340	+·0193	·9685	+·0212	·8829	+·0264	·7892	+·0327	·6873	+·0332	·5670	+·0223	·5591	+·0180	·6144	+·0187	·7040	+·0210	·8531	+·0268	·9980	+·0279	1·0510	+·0239	·8091	+·0243
8	1·0630	+·0483	·9950	+·0477	·9116	+·0551	·8114	+·0549	·7040	+·0499	·5795	+·0348	·5720	+·0309	·6298	+·0341	·7218	+·0388	·8755	+·0492	1·0219	+·0518	1·0785	+·0514	·8305	+·0457
9	1·0870	+·0723	1·0180	+·0707	·9289	+·0724	·8250	+·0685	·7126	+·0585	·5867	+·0420	·5788	+·0377	·6394	+·0437	·7362	+·0532	·8877	+·0614	1·0394	+·0693	1·0992	+·0721	·8449	+·0601
10	1·0930	+·0783	1·0268	+·0795	·9325	+·0760	·8258	+·0693	·7117	+·0576	·5861	+·0414	·5801	+·0390	·6110	+·0153	·7365	+·0535	·8867	+·0604	1·0368	+·0667	1·1003	+·0732	·8465	+·0617
11	1·0748	+·0601	1·0140	+·0667	·9213	+·0648	·8146	+·0581	·6999	+·0458	·5785	+·0338	·5731	+·0320	·6324	+·0367	·7255	+·0425	·8693	+·0430	1·0164	+·0463	1·0816	+·0545	·8334	+·0486
12	1·0456	+·0309	·9867	+·0394	·8965	+·0400	·7946	+·0381	·6830	+·0289	·5642	+·0195	·5596	+·0185	·6168	+·0211	·7051	+·0221	·8446	+·0183	·9884	+·0183	1·0500	+·0229	·8113	+·0265
13	1·0115	—·0032	·9537	+·0064	·8659	+·0094	·7657	+·0092	·6595	+·0054	·5450	+·0003	·5416	+·0005	·5966	+·0009	·6785	—·0045	·8160	—·0103	·9562	—·0139	1·0163	—·0108	·7839	—·0009
14	·9951	—·0196	·9232	—·0241	·8343	—·0222	·7361	—·0204	·6326	—·0215	·5247	—·0200	·5209	—·0202	·5732	—·0225	·6523	—·0307	·7911	—·0352	·9336	—·0365	·9919	—·0352	·7583	—·0265
15	·9980	—·0167	·9024	—·0449	·8410	—·0155	·7391	—·0174	·6094	—·0447	·5061	—·0386	·5030	—·0381	·5833	—·0124	·6324	—·0506	·7765	—·0498	·9213	—·0488	·9776	—·0495	·7691	—·0157
16	·9612	—·0535	·8925	—·0548	·7995	—·0570	·6908	—·0657	·5904	—·0637	·4906	—·0541	·4891	—·0520	·5372	—·0585	·6240	—·0590	·7752	—·0511	·9184	—·0517	·9735	—·0536	·7285	—·0563
17	·9660	—·0487	·8933	—·0540	·7965	—·0600	·6869	—·0696	·5855	—·0686	·4900	—·0547	·4885	—·0526	·5370	—·0587	·6270	—·0560	·7817	—·0446	·9272	—·0429	·9807	—·0464	·7300	—·0548
18	·9747	—·0400	·9007	—·0466	·8030	—·0535	·6980	—·0585	·5983	—·0558	·5004	—·0443	·4989	—·0422	·5806	—·0151	·6401	—·0429	·7906	—·0357	·9379	—·0322	·9921	—·0350	·7404	—·0444
19	·9911	—·0236	·9151	—·0322	·8197	—·0368	·7182	—·0383	·6204	—·0337	·5203	—·0244	·5180	—·0231	·5684	—·0273	·6596	—·0234	·8094	—·0169	·9563	—·0138	1·0089	—·0182	·7587	—·0261
20	1·0087	—·0060	·9354	—·0119	·8415	—·0150	·7408	—·0157	·6443	—·0098	·5416	—·0031	·5384	—·0027	·5928	—·0029	·6842	+·0012	·8291	+·0028	·9728	+·0027	1·0248	—·0023	·7796	—·0052
21	1·0214	+·0067	·9507	+·0034	·8605	+·0040	·7629	+·0064	·6622	+·0081	·5586	+·0139	·5577	+·0166	·6135	+·0178	·7030	+·0200	·8418	+·0155	·9833	+·0132	1·0371	+·0100	·7960	+·0112
22	1·0266	+·0119	·9580	+·0107	·8701	+·0136	·7730	+·0165	·6727	+·0186	·5709	+·0262	·5709	+·0298	·6267	+·0310	·7111	+·0281	·8461	+·0198	·9871	+·0170	1·0424	+·0153	·8047	+·0199
23	1·0223	+·0076	·9556	+·0083	·8680	+·0115	·7677	+·0112	·6707	+·0166	·5697	+·0250	·5703	+·0292	·6252	+·0295	·7073	+·0243	·8422	+·0159	·9815	+·0114	1·0369	+·0098	·8015	+·0167
Mean ...	1·0147		·9473		·8565		·7565		·6541		·5447		·5411		·5957		·6830		·8263		·9701		1·0271		·7848	

TABLE II.—*Rectangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at Calcutta, computed from Table I.*

MONTHS.	$U' \sin u'$	$U' \cos u'$	$U'' \sin u''$	$U'' \cos u''$	$U'' \sin u'''$	$U''' \cos u'''$	$U'''' \sin u''''$	$U'''' \cos u''''$
January	—·01421	+·02492	+·01889	—·03650	—·00037	+·00767	—·00263	—·00195
February	—·01731	+·02686	+·02317	—·03511	—·00052	+·00534	—·00100	—·00166
March	—·01746	+·02957	+·02395	—·03651	+·00047	+·00198	—·00108	—·00072
April	—·01416	+·03319	+·02335	—·03545	—·00124	—·00162	—·00083	+·00087
May	—·00858	+·03140	+·02028	—·03272	—·00123	—·00378	—·00088	+·00152
June	—·00096	+·02177	+·01861	—·02799	—·00033	—·00369	—·00071	+·00108
July	+·00071	+·01924	+·01950	—·02747	—·00027	—·00361	—·00052	+·00043
August	+·00003	+·02185	+·02160	—·03026	—·00080	—·00307	—·00088	+·00045
September	—·00215	+·02310	+·01914	—·03514	—·00108	+·00010	—·00113	—·00005
October	—·00677	+·02243	+·01282	—·03718	+·00090	+·00280	—·00108	—·00121
November	—·00950	+·02309	+·01076	—·03844	+·00049	+·00520	—·00228	—·00139
December	—·01128	+·02454	+·01478	—·03832	+·00049	+·00707	—·00227	—·00193
Mean ...	—·00847	+·02516	+·01890	—·03428	—·00029	+·00120	—·00127	—·00038

TABLE III.—*Values of rectangular co-ordinates from Table II, corrected as annual series.*

MONTHS.	$U' \sin u'$	$U' \cos u'$	$U'' \sin u''$	$U'' \cos u''$	$U''' \sin u'''$	$U''' \cos u'''$	$U'''' \sin u''''$	$U'''' \cos u''''$
January	—·01430	+·02519	+·01921	—·03645	—·00042	+·00759	—·00226	—·00202
February	—·01736	+·02674	+·02280	—·03552	—·00029	+·00537	—·00131	—·00165
March	—·01725	+·02954	+·02430	—·03632	+·00013	+·00199	—·00087	—·00068
April	—·01448	+·03340	+·02305	—·03573	—·00091	—·00165	—·00093	+·00079
May	—·00822	+·03102	+·02045	—·03239	—·00147	—·00375	—·00088	+·00161
June	—·00129	+·02219	+·01855	—·02832	—·00027	—·00369	—·00064	+·00101
July	+·00092	+·01885	+·01949	—·02715	—·00013	—·00365	—·00060	+·00045
August	—·00003	+·02215	+·02164	—·03052	—·00111	—·00298	—·00086	+·00048
September	—·00224	+·02301	+·01908	—·03496	—·00066	—·00003	—·00105	—·00013
October	—·00657	+·02233	+·01281	—·03727	+·00049	+·00295	—·00127	—·00109
November	—·00974	+·02330	+·01087	—·03841	+·00081	+·00505	—·00198	-·00152
December	—·01108	+·02424	+·01455	—·03832	+·00034	+·00719	—·00263	—·00183
Year ...	—·00847	+·02516	+·01891	—·03427	—·00029	+·00119	—·00128	—·00038

TABLE IV.—*Constant coefficients of the periodical formula, computed from Tables I and III.*

MONTHS.	Mean.	U'	u'	U''	u''	U'''	u'''	U''''	u''''
	29+								
January	1·0135	·02897	330°25′	·04110	152°38′	·00761	356°48′	·00303	228°19′
February	·9496	·03188	327° 0′	·04232	146°48′	·00538	356°55′	·00211	218°32′
March	·8533	·03421	329°43′	·04370	146°13′	·00199	3°44′	·00110	231°54′
April	·7604	·03640	336°33′	·04252	147°10′	·00189	208°43′	·00122	310°12′
May	·6503	·03209	345°10′	·03831	147°44,	·00403	201°26′	·00183	331°11′
June	·5480	·02223	356°41′	·03386	146°46′	·00370	184°10′	·00120	327°50′
July	*·5387*	*·01887*	*2°48′*	*·03342*	*144°20*	*·00365*	*182° 0′*	*·00075*	*307°10′*
August	·5972	·02215	359°55′	·03741	144°40′	·00318	200°26′	·00098	299°11′
September	·6825	·02312	354°27′	·04002	151°25′	·00067	267° 4′	·00106	262°47′
October	·8262	·02327	343°36′	·03933	160°58′	·00299	9°21′	·00168	229°18′
November	·9705	·02525	337°19′	·03992	164°22′	·00511	9° 8′	·00250	232°27′
December	1·0274	·02665	335°26′	·04107	158°55′	·00720	2°44′	·00320	235°15′
Year ...	·7848	·02655	341°24′	·03914	151° 7′	·00123	346° 9′	·00134	253°42′

TABLE V.—*Hourly variation of pressure at Calcutta, computed with the corrected constants of Table IV.*

Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Midnight	+·0019	+·0042	+·0062	+·0067	+·0099	+·0164	+·0197	+·0196	+·0152	+·0054	—·0002	+·0014	+·0088
1	—·0070	—·0060	—·0056	—·0049	—·0012	+·0042	+·0065	+·0063	+·0017	—·0073	—·0115	—·0084	—·0029
2	—·0149	—·0162	—·0177	—·0158	—·0114	—·0078	—·0066	—·0067	—·0108	—·0175	—·0200	—·0165	—·0135
3	—·0208	—·0235	—·0254	—·0219	—·0170	—·0153	—·0150	—·0153	—·0188	—·0231	—·0238	—·0216	—·0201
4	—·0230	—·0254	—·0257	—·0201	—·0148	—·0155	—·0164	—·0169	—·0199	—·0214	—·0219	—·0225	—·0202
5	—·0186	—·0193	—·0164	—·0086	—·0042	—·0075	—·0099	—·0105	—·0123	—·0119	—·0123	—·0163	—·0123
6	—·0036	—·0032	+·0023	+·0112	+·0134	+·0067	+·0025	+·0027	+·0027	+·0052	+·0056	—·0004	+·0038
7	+·0213	+·0218	+·0278	+·0346	+·0331	+·0229	+·0173	+·0192	+·0227	+·0275	+·0296	+·0250	+·0252
8	+·0501	+·0498	+·0534	+·0558	+·0491	+·0361	+·0303	+·0345	+·0415	+·0485	+·0535	+·0524	+·0462
9	+·0718	+·0715	+·0718	+·0687	+·0573	+·0427	+·0377	+·0442	+·0536	+·0613	+·0679	+·0712	+·0600
10	+·0765	+·0782	+·0763	+·0699	+·0561	+·0417	+·0380	+·0453	+·0540	+·0601	+·0661	+·0724	+·0612
11	+·0612	+·0663	+·0650	+·0588	+·0465	+·0336	+·0312	+·0377	+·0423	+·0438	+·0472	+·0540	+·0490
Noon	+·0313	+·0396	+·0406	+·0375	+·0293	+·0196	+·0181	+·0218	+·0210	+·0176	+·0176	+·0230	+·0204
13	—·0026	+·0066	+·0094	+·0095	+·0060	+·0008	+·0003	+·0007	—·0019	—·0109	—·0129	—·0102	—·0007
14	—·0305	—·0236	—·0213	—·0208	—·0206	—·0204	—·0196	—·0229	—·0300	—·0345	—·0364	—·0359	—·0263
15	—·0476	—·0447	—·0454	—·0477	—·0460	—·0401	—·0380	—·0439	—·0492	—·0487	—·0490	—·0498	—·0459
16	—·0532	—·0550	—·0595	—·0653	—·0634	—·0533	—·0502	—·0575	—·0589	—·0526	—·0509	—·0529	—·0560
17	—·0495	—·0547	—·0616	—·0692	—·0672	—·0553	—·0523	—·0591	—·0567	—·0469	—·0441	—·0469	—·0553
18	—·0388	—·0458	—·0527	—·0590	—·0562	—·0451	—·0427	—·0477	—·0433	—·0334	—·0310	—·0344	—·0442
19	—·0233	—·0308	—·0356	—·0384	—·0343	—·0255	—·0237	—·0262	—·0219	—·0157	—·0144	—·0180	—·0256
20	—·0071	—·0132	—·0152	—·0148	—·0099	—·0031	—·0013	—·0017	+·0009	+·0023	+·0017	—·0012	—·0052
21	+·0058	+·0019	+·0026	+·0045	+·0093	+·0151	+·0177	+·0186	+·0188	+·0157	+·0129	+·0106	+·0112
22	+·0113	+·0106	+·0129	+·0147	+·0185	+·0247	+·0282	+·0291	+·0272	+·0203	+·0159	+·0146	+·0190
23	+·0092	+·0109	+·0138	+·0146	+·0177	+·0244	+·0282	+·0287	+·0251	+·0162	+·0104	+·0104	+·0174

TABLE VI.—*Diurnal epochs of maximum and minimum pressures at Calcutta.*

Months.	1st Minimum.		1st Maximum.		2nd Minimum.		2nd Maximum.	
	hrs.	mins.	hrs.	mins.	hrs.	mins.	hrs.	mins.
January	3	55	9	44	16	4	22	12
February	3	47	9	52	16	28	22	31
March	3	33	9	47	16	41	22	35
April	3	19	9	35	16	46	22	29
May	3	17	9	23	16	45	22	24
June	3	32	9	22	16	40	22	28
July	3	41	9	33	16	40	22	30
August	3	42	9	38	16	37	22	27
September	3	37	9	33	16	19	22	17
October	3	18	9	25	15	52	22	0
November	3	12	9	24	15	41	21	49
December	3	41	9	34	15	48	21	57
Year	3	32	9	35	16	26	22	19

TABLE VII.—*Mean monthly and annual values of the diurnal maximum and minimum pressures at the above epochs.*

Months.	1st Minimum.	1st Maximum.	2nd Minimum.	2nd Maximum.
	Inch.	Inch.	Inch.	Inch.
January	—·0231	+·0772	—·0533	+·0115
February	—·0256	+·0783	—·0560	+·0117
March	—·0267	+·0767	—·0622	+·0145
April	—·0224	+·0709	—·0697	+·0158
May	—·0173	+·0580	—·0678	+·0192
June	—·0165	+·0433	—·0560	+·0258
July	—·0169	+·0389	—·0529	+·0295
August	—·0173	+·0460	—·0601	+·0302
September	—·0205	+·0554	—·0595	+·0277
October	—·0233	+·0626	—·0526	+·0204
November	—·0240	+·0694	—·0513	+·0160
December	—·0229	+·0744	—·0530	+·0146
Year	—·0212	+·0624	—·0571	+·0195

HAZÁRIBÁGH.—Hazáribágh is situated in latitude 24°, at an elevation of 2,000 feet, on the highest part of the plateau that rises to the west of the Gangetic delta, and extends between it and the Sone valley. From the Gangetic delta on the east, and from the main stream of the Ganges on the north, the ascent is very gentle; but it is more abrupt from the Sone, on the west; and to the south of Hazáribágh there is a tolerably rapid descent to the valley of the Damuda, which divides the highlands of Hazáribágh from those of Chutia Nágpur. The plateau bears some isolated hills of considerable elevation, the highest being Parasnath, 4,483 feet; but there are none in the immediate neighbourhood of Hazáribágh, which is simply the highest part of the plateau, north of the Damuda. In virtue of its position, it is very dry during the greater part of the year. The surface has been denuded of jungle to a distance of a couple of miles, or more, all round the station; and one or two tanks of moderate size, which store the local rainfall, offer the only extended water-surfaces within many miles. In the rainy season, however, the south-east wind from the Bay of Bengal blows up across the plateau, and brings heavy

rain; the average fall of July and August being fully as great as that of Calcutta. But in March and April, during the prevalence of the hot winds, the dryness of the air is excessive, observations, showing only 5 and 6 per cent. of relative humidity, being frequently recorded at 4 P.M. At this season, the average daily range of temperature in the shade is not less than 25° or 26°, and the mean temperature is nearly as high as at Berhampore, nearly 2,000 feet lower.

The diurnal variation of Hazáribágh is derived from a much less extensive series of observations than that of Calcutta. Up to the time that the calculation was undertaken, hourly observations had been recorded on four days in each month, for three years (January 1873 to December 1875), thus affording 12 sets of readings for each month. But for three years before these were begun, *viz.*, 1869 to 1871, readings of the barometer had been recorded daily at intervals of six hours; *viz.*, at 4 and 10 A.M. and P.M., which hours are very near those of the maximum and minimum pressure. For these hours, therefore, we have an average of 90 sets of observations for each month. The observations have not all been recorded with the same kind of barometer. Up to May 1871, a mountain barometer, by Adie, with a tube of about 0·25 in diameter, was in use at Hazáribágh; and, after that date, a small standard, by Casella, having a tube 0·4 inch diameter. The hourly readings have been recorded exclusively with the latter instrument. Of the six-hourly observations, only nine months were registered with the latter, and the remainder with the former instrument. But it does not appear that the change of the instrument has much affected the apparent diurnal range of pressure. The mean diurnal range of two entire years (between 10 A.M. and 4 P.M.,) measured by the mountain barometer, amounted to ·0962 inch; that of three entire years, measured by the standard, to ·0964 inch. The data, above enumerated, have been dealt with in the following manner.

Each set of hourly observations begins and ends at midnight, and consists of 25 readings of the barometer. In the first place, the hourly mean of the twelve sets of observations in each month has been taken, and any difference that might remain between the initial and final midnight means was distributed throughout by simple interpolation.* The values thus obtained, together with the hourly variation from the monthly mean, are given in Table VIII. In the next place, the variations of the four hours, 4 and 10, A.M., and P.M., derived from the three years' six-hourly observations, were substituted for those of Table VIII; care being taken to allow for the difference between the mean of the 24 hourly observations and that of the four observations only; and the values of the intervening hours were corrected by simple interpolation, according to the formula given at page 63. These values are given in Table IX, and have served as the basis of the further calculation.

The further procedure has been identical with that followed in the case of Calcutta, already described, and the successive results are given in Tables X to XV. The column of monthly mean pressures in Table XII is deduced directly from the observations of ten years and has not been computed by the periodical formula.

* This difference in most cases did not exceed a few thousandths. It was as follows in each month:—

January ...	—·002	April ...	—·004	July ...	—·007	October ...	+·007
February ...	—·002	May ...	+·022	August ...	+·009	November ...	—·018
March ...	+·013	June ...	—·005	September ...	+·003	December ...	—·023

TABLE VIII.—*Mean hourly pressures and hourly variation of pressure at Házáribágh.*

Means of twelve series of hourly readings in each month.

Hours.	January. Mean. 27+	January. Diff.	February. Mean. 27+	February. Diff.	March. Mean. 27+	March. Diff.	April. Mean. 27+	April. Diff.	May. Mean. 27+	May. Diff.	June. Mean. 27+	June. Diff.
0	·962	+ ·004	·926	+ ·011	·846	+ ·005	·761	+ ·004	·699	+ ·001	·577	+ ·012
1	·960	+ ·002	·918	+ ·003	·834	− ·007	·757	·000	·690	− ·008	·569	+ ·004
2	·955	− ·003	·906	− ·009	·826	− ·015	·747	− ·010	·683	− ·015	·560	− ·005
3	·944	− ·014	·895	− ·020	·819	− ·022	·741	− ·016	·678	− ·020	·552	− ·013
4	·935	− ·023	·888	− ·027	·816	− ·025	·742	− ·015	·681	− ·017	·548	− ·017
5	·933	− ·025	·889	− ·026	·823	− ·018	·751	− ·006	·690	− ·008	·555	− ·010
6	·940	− ·018	·900	− ·015	·839	− ·002	·769	+ ·012	·706	+ ·008	·571	+ ·006
7	·966	+ ·008	·924	+ ·009	·859	+ ·018	·786	+ ·029	·725	+ ·027	·584	+ ·019
8	·986	+ ·028	·945	+ ·030	·883	+ ·042	·803	+ ·046	·710	+ ·012	·597	+ ·032
9	1·007	+ ·049	·965	+ ·050	·899	+ ·058	·814	+ ·057	·751	+ ·053	·600	+ ·035
10	1·019	+ ·061	·977	+ ·062	·903	+ ·062	·814	+ ·057	·754	+ ·056	·604	+ ·039
11	1·009	+ ·051	·970	+ ·055	·892	+ ·051	·805	+ ·048	·745	+ ·047	·597	+ ·032
12	·987	+ ·029	·950	+ ·035	·873	+ ·032	·788	+ ·031	·733	+ ·035	·586	+ ·021
13	·958	·000	·923	+ ·008	·845	+ ·004	·764	+ ·007	·711	+ ·013	·567	+ ·002
14	·938	− ·020	·899	− ·016	·819	− ·022	·737	− ·020	·688	− ·010	·549	− ·016
15	·924	− ·034	·879	− ·036	·800	− ·041	·713	− ·044	·668	− ·030	·530	− ·035
16	·920	− ·038	·873	− ·042	·794	− ·047	·702	− ·055	·649	− ·049	·517	− ·048
17	·924	− ·034	·874	− ·041	·797	− ·044	·700	− ·057	·643	− ·055	·520	− ·045
18	·933	− ·025	·881	− ·034	·805	− ·036	·706	− ·051	·650	− ·048	·527	− ·038
19	·945	− ·013	·894	− ·021	·818	− ·023	·721	− ·036	·664	− ·034	·541	− ·024
20	·958	·000	·910	− ·005	·837	− ·004	·743	− ·014	·686	− ·012	·560	− ·005
21	·965	+ ·007	·923	+ ·008	·853	+ ·012	·759	+ ·002	·700	+ ·002	·579	+ ·014
22	·967	+ ·009	·929	+ ·014	·859	+ ·018	·768	+ ·011	·709	+ ·011	·589	+ ·024
23	·968	+ ·010	·930	+ ·015	·855	+ ·014	·767	+ ·010	·708	+ ·010	·586	+ ·021
Mean ...	·958		·915		·841		·757		·698		·565	

Hours.	July. Mean. 27+	July. Diff.	August. Mean. 27+	August. Diff.	September. Mean. 27+	September. Diff.	October. Mean. 27+	October. Diff.	November. Mean. 27+	November. Diff.	December. Mean. 27+	December. Diff.
0	·572	+ ·014	·650	+ ·015	·711	+ ·014	·846	·000	·992	+ ·005	·999	− ·003
1	·562	+ ·004	·639	+ ·004	·704	+ ·007	·841	− ·005	·988	+ ·001	·994	− ·008
2	·550	− ·008	·628	− ·007	·696	− ·001	·832	− ·014	·981	− ·006	·989	− ·013
3	·539	− ·019	·618	− ·017	·685	− ·012	·824	− ·022	·971	− ·016	·981	− ·021
4	·536	− ·022	·615	− ·020	·680	− ·017	·820	− ·026	·965	− ·022	·975	− ·027
5	·541	− ·017	·624	− ·011	·685	− ·012	·826	− ·020	·968	− ·019	·978	− ·024
6	·557	− ·001	·636	+ ·001	·699	+ ·002	·840	− ·006	·979	− ·008	·988	− ·014
7	·571	+ ·013	·652	+ ·017	·715	+ ·018	·862	+ ·016	·999	+ ·012	1·008	+ ·006
8	·581	+ ·023	·667	+ ·032	·733	+ ·036	·885	+ ·039	1·021	+ ·034	1·033	+ ·031
9	·588	+ ·030	·678	+ ·043	·745	+ ·048	·900	+ ·054	1·040	+ ·053	1·055	+ ·053
10	·591	+ ·033	·680	+ ·045	·747	+ ·050	·904	+ ·058	1·048	+ ·061	1·066	+ ·064
11	·588	+ ·030	·673	+ ·038	·738	+ ·041	·892	+ ·046	1·006	+ ·019	1·054	+ ·052
12	·578	+ ·020	·659	+ ·024	·722	+ ·025	·872	+ ·026	1·017	+ ·030	1·033	+ ·031
13	·563	+ ·005	·636	+ ·001	·692	− ·005	·848	+ ·002	·989	+ ·002	1·003	+ ·001
14	·547	− ·011	·615	− ·020	·669	− ·028	·828	− ·018	·961	− ·026	·984	− ·018
15	·528	− ·030	·601	− ·034	·649	− ·048	·815	− ·031	·947	− ·040	·970	− ·032
16	·519	− ·039	·591	− ·044	·638	− ·059	·807	− ·039	·943	− ·044	·966	− ·036
17	·518	− ·040	·589	− ·046	·643	− ·054	·812	− ·034	·949	− ·038	·968	− ·034
18	·527	− ·031	·594	− ·041	·655	− ·042	·816	− ·030	·954	− ·033	·974	− ·028
19	·540	− ·018	·610	− ·025	·678	− ·019	·827	− ·019	·967	− ·020	·987	− ·015
20	·562	+ ·004	·629	− ·006	·699	+ ·002	·843	− ·003	·984	− ·003	1·000	− ·002
21	·579	+ ·021	·634	− ·001	·714	+ ·017	·853	+ ·007	·996	+ ·009	1·012	+ ·010
22	·584	+ ·026	·662	+ ·027	·720	+ ·023	·857	+ ·011	·999	+ ·012	1·020	+ ·018
23	·581	+ ·023	·659	+ ·024	·716	+ ·019	·854	+ ·008	·998	+ ·011	1·016	+ ·014
Mean ...	·558		·635		·697		·846		·987		1·002	

TABLE IX.—*Hourly variation of pressure at Házaribágh corrected to the three years' means of six-hourly readings.*

Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Midnight	+·007	+·019	+·008	+·008	+·008	+·014	+ 17	+0·18	+·013	+·012	+·011	+·004
1	+·004	+·011	—·004	+·004	—·001	+·006	+·007	+·007	+·006	+·007	+·006	—·001
2	—·003	—·001	—·013	—·007	—·009	—·003	—·005	—·004	—·003	—·003	—·001	—·006
3	—·015	—·012	—·021	—·013	—·015	—·011	—·015	—·015	—·015	—·011	—·012	—·013
4	—·025	—·019	—·024	—·013	—·013	—·015	—·018	—·018	—·021	—·016	—·019	—·019
5	—·026	—·020	—·017	—·006	—·006	—·009	—·014	—·013	—·015	—·014	—·019	—·018
6	—·019	—·010	—·001	+·011	+·009	+·005	·000	+·001	·000	—·005	—·010	—·009
7	+·008	+·012	+·020	+·026	+·026	+·017	+·013	+·016	+·017	+ 013	+·007	+·009
8	+·028	+·032	+·044	+·041	+·039	+·028	+·022	+·030	+·036	+·031	+·027	+·033
9	+·050	+·050	+·060	+·051	+·049	+·030	+·027	+·040	+·049	+·042	+·043	+·053
10	+·062	+·061	+·064	+·049	+·050	+·032	+·029	+·041	+·052	+·042	+·049	+·063
11	+·052	+·052	+·052	+·042	+·041	+·026	+·026	+·035	+·043	+·032	+·040	+·050
Noon	+·027	+·030	+·031	+·027	+·028	+·016	+·016	+·021	+·026	+·013	+·023	+·029
13	—·003	+·(02	+·002	+ 004	+·006	—·002	+·001	—·001	—·004	—·009	—·002	—·002
14	—·025	—·024	—·026	—·021	—·018	—·019	—·016	—·022	—·028	—·028	—·028	—·022
15	—·041	—·046	—·046	—·043	—·038	—·037	—·035	—·035	—·048	—·039	—·039	—·036
16	—·046	—·(54	—·054	—·052	—·058	—·049	—·044	—·045	—·050	—·046	—·041	—·041
17	—·041	—·052	—·049	—·054	—·061	—·046	—·044	—·046	—·054	—·038	—·034	—·037
18	—·030	—·039	—·039	—·047	—·051	—·038	—·034	—·040	—·042	—·030	—·028	—·029
19	—·015	—·023	—·025	—·032	—·034	—·024	—·020	—·024	—·019	—·016	—·015	—·015
20	·000	—·004	—·004	—·010	—·009	—·004	+·004	—·004	+·003	+·004	+·003	·000
21	+·012	+·013	+·014	+·007	+·008	+·015	+·022	+·002	+·018	+·017	+·016	+·014
22	+·016	+·022	+·023	+·016	+·020	+·026	+·028	+·031	+·024	+·024	+·020	+·024
23	+·018	+·023	+·018	+·015	+·018	+·023	+·025	+·028	+·019	+·021	+·018	+·020

TABLE X.—*Rectangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at Házaribágh, computed from Table IX.*

MONTHS.	$U'\sin u'$.	$U'\cos u'$.	$U''\sin u''$.	$U''\cos u''$.	$U'''\sin u'''$.	$U'''\cos u'''$.	$U''''\sin u''''$.	$U''''\cos u''''$.
January	—·0071	+·0152	+·0213	—·0300	—·0006	+·0087	—·0022	+·0012
February	—·0040	+·0205	+·0248	—·0303	—·0017	+·0052	—·0007	—·0006
March	—·0094	+·0221	+·0202	—·0348	—·0008	+·0027	—·0012	—·0013
April	—·0067	+·0268	+·0183	—·0274	—·0007	—·0012	—·0003	+·0006
May	—·0063	+·0267	+·0215	—·0282	—·0017	—·0040	—·0014	+·0006
June	+·0016	+·0176	+·0167	—·0237	—·0006	—·0033	+·0002	—·0008
July	+·0030	+·0129	+·0175	—·0241	—·0010	—·0037	—·0002	+·0013
August	—·0011	+·0186	+·0198	—·0257	+·0019	—·0011	+·0004	—·0011
September	—·0020	+·0214	+·0201	—·0324	—·0026	+·0023	—·0010	+·0014
October	+·0010	+·0160	+·0152	—·0274	+·0001	+·0031	—·0021	—·0004
November	—·0024	+·0140	+·0178	—·0269	—·0012	+·0059	—·0014	—·0012
December	—·0076	+ 0157	+·0187	—·0298	—·0016	+·0059	—·0030	—·0033
Mean ...	—·00342	+·01896	+·01933	—·02839	—·00088	+·00171	—·00108	—·00030

TABLE XI.—*Values of rectangular co-ordinates from Table X, corrected as annual series.*

MONTHS.	$U'\sin u'$.	$U'\cos u'$.	$U''\sin u''$.	$U''\cos u''$.	$U'''\sin u'''$.	$U'''\cos u'''$.	$U''''\sin u''''$.	$U''''\cos u''''$.
January	—·00625	+·01606	+·02157	—·02946	—·00109	+·00774	—·00232	+·00067
February	—·00526	+·01963	+·02451	—·03122	—·00108	+·00587	—·00088	—·00030
March	—·00791	+·02281	+·02033	—·03345	—·00129	+·00244	— 00075	—·00144
April	—·00819	+·02638	+·01850	—·02906	—·00060	—·00133	—·00097	+·00069
May	—·00504	+·02679	+·02095	—·02638	— 00127	—·00358	—·00068	+·00042
June	+·00074	+·01780	+·01758	—·02544	—·00158	—·00384	—·00045	—·00038
July	+·00339	+·01254	+·01643	—·02262	+ 00037	—·00328	+ 00022	+·00056
August	—·00108	+·01899	+·02091	—·02678	+·00038	—·00121	+ 00026	—·00007
September	—·00225	+·02117	+·01917	—·03173	—·00125	+·00202	—·00115	+·00021
October	+·00125	+·01594	+·01582	—·02774	— 00088	+·00379	—·00176	+·00078
November	—·00242	+ 01439	+·01755	—·02670	—·00075	+ 00492	—·00182	—·00222
December	—·00798	+·01502	+·01864	—·03006	—·00152	+·00698	—·00268	—·00252
Year ...	—·00342	+ 01896	+·01933	—·02839	—·00088	+·00171	— 00108	—·00030

TABLE XII.—*Constant co-efficients of the periodical formula, computed from Table XI.*

MONTHS.	Mean.*	U'	u'	U''	u''	U'''	u'''	U''''	u''''
	27+								
January ...	·963	·01723	338° 44′	·03651	143° 47′	·00782	351° 59′	·00241	286° 6′
February ...	·923	·02032	345° 0′	·03969	141° 52′	·00597	349° 35′	·00093	251° 11′
March ...	·856	·02414	340° 52′	·03914	148° 43′	·00276	332° 8′	·00162	207° 31′
April ...	·764	·02762	342° 45′	·03445	147° 31′	·00146	204° 17′	·00119	305° 26′
May ...	·677	·02726	349° 21′	·03369	141° 33′	·00380	199° 32′	·00080	301° 42
June ...	·568	·01782	2° 23′	·03092	145° 21′	·00415	202° 22′	·00059	229° 49′
July ...	·555	·01299	15° 8′	·02796	144° 0′	·00330	173° 34′	·00060	21° 27′
August ...	·623	·01902	356° 45′	·03398	142° 1′	·00127	162° 34′	·00027	105° 4′
September ...	·700	·02129	353° 56′	·03707	148° 52′	·00238	328° 15′	·00117	280° 21′
October ...	·857	·01599	4° 29′	·03194	150° 18′	·00389	346° 56′	·00193	293° 54′
November ...	·973	·01459	350° 27′	·03195	146° 41′	·00498	351° 20′	·00287	219° 21′
December ...	1·002	·01701	332° 1′	·03537	148° 12′	·00714	347° 43′	·00368	226° 46′
Year ...	·788	·01927	349° 46′	·03435	145° 45′	·00192	332° 46′	·00112	254° 29′

* These values are the means of ten years' observations.

TABLE XIII.—*Hourly variation of pressure at Házaribágh, computed with the corrected constants of Table XII.*

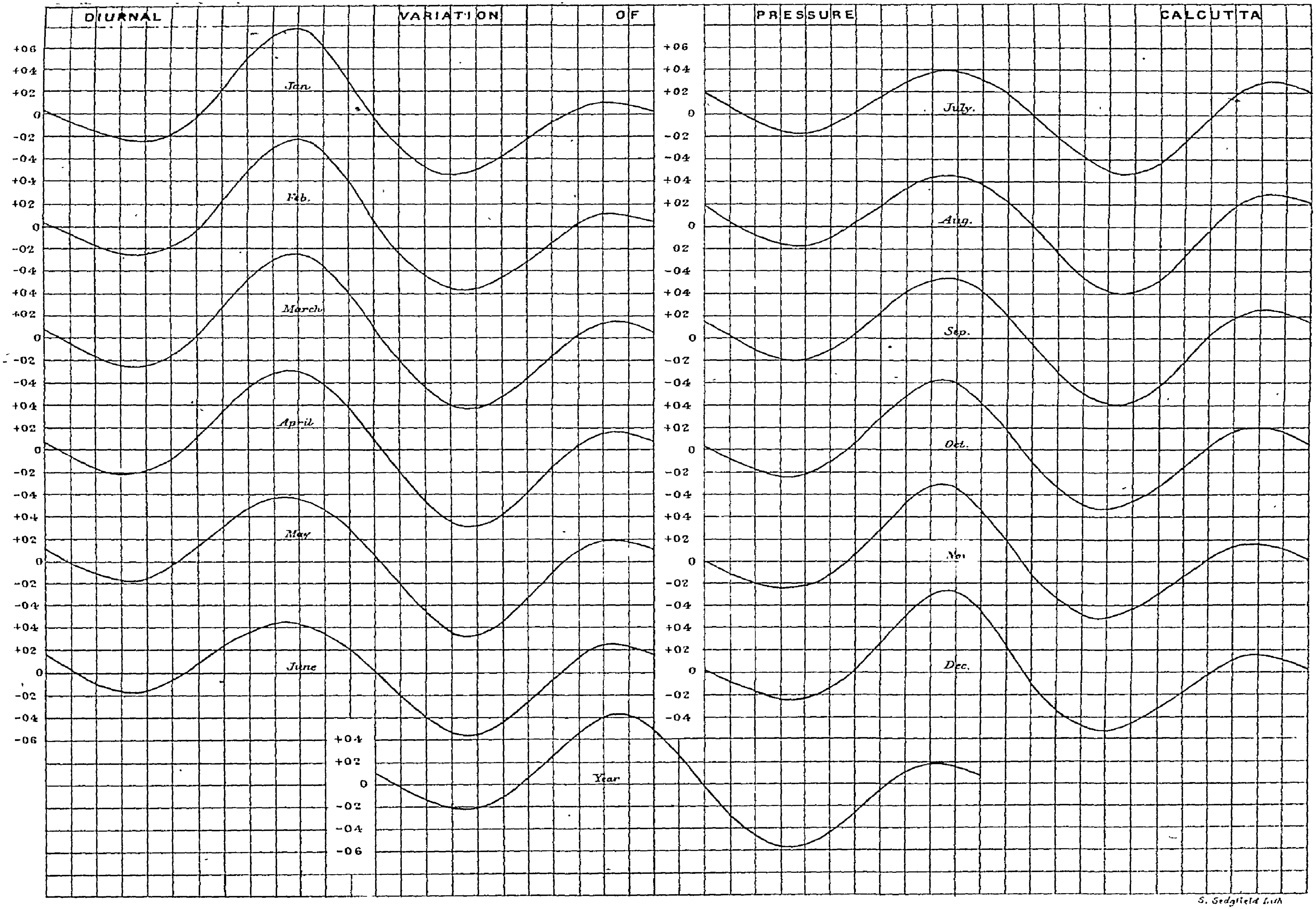
Hours.	January	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Midnight	+·0119	+·0173	+·0104	+·0087	+·0140	+·0163	+·0204	+·0205	+·0145	+·0144	+·0126	+·0065	+·0139
1	+·0062	+·0083	—·0017	—·0008	+·0036	+·0034	+·0080	+·0081	+·0042	+·0070	+·0034	—·0024	+·0039
2	—·0026	—·0035	—·0127	—·0101	—·0062	—·0076	—·0051	—·0056	—·0065	—·0017	—·0053	—·0100	—·0064
3	—·0140	—·0153	—·0195	—·0157	—·0120	—·0135	—·0142	—·0155	—·0149	—·0105	—·0124	—·0164	—·0145
4	—·0238	—·0231	—·0204	—·0152	—·0114	—·0129	—·0162	—·0182	—·0182	—·0164	—·0171	—·0213	—·0179
5	—·0260	—·0228	—·0143	—·0069	—·0010	—·0066	—·0109	—·0127	—·0139	—·0155	—·0172	—·0217	—·0144
6	—·0156	—·0116	—·0007	+·0[illegible]2	+·0087	+·0036	—·0004	—·0005	—·0012	—·0054	—·0099	—·0133	—·0032
7	+·0064	+·0091	+·0189	+·0267	+·0239	+·0155	+·0115	+·0151	+·0176	+·0117	+·0058	+·0059	+·0140
8	+·0324	+·0335	+·0404	+·0433	+·0375	+·0266	+·0213	+·0299	+·0369	+·0300	+·0263	+·0314	+·0325
9	+·0523	+·0531	+·0567	+·0531	+·0461	+·0341	+·0268	+·0401	+·0500	+·0419	+·0431	+·0529	+·0459
10	+·0581	+·0602	+·0615	+·0533	+·0175	+·0358	+·0273	+·0428	+·0520	+·0428	+·0189	+·0603	+·0492
11	+·0481	+·0517	+·0514	+·0437	+·0408	+·0303	+·0226	+·0365	+·0417	+·0322	+·0396	+·0496	+·0407
Noon	+·0266	+·0300	+·0288	+·0263	+·0266	+·0180	+·0129	+·0219	+·0215	+·0137	+·0189	+·0255	+·0226
13	+·0006	+·0015	+·0002	+·0041	+·0063	+·0005	—·0009	+·0015	—·0035	—·0078	—·0053	—·0025	—·0004
14	—·0233	—·0257	—·0267	—·0196	—·0171	—·0190	—·0169	—·0203	—·0278	—·0274	—·0254	—·0251	—·0229
15	—·0403	—·0154	—·0159	—·0404	—·0395	—·0365	—·0315	—·0386	—·0463	—·0414	—·0374	—·0384	—·0101
16	—·0476	—·0540	—·0546	—·0539	—·0553	—·0476	—·0406	—·0492	—·0551	—·0470	—·0411	—·0424	—·0190
17	—·0443	—·0512	—·0526	—·0534	—·0600	—·0491	—·0410	—·0500	—·0525	—·0128	—·0379	—·0389	—·0481
18	—·0322	—·0391	—·0414	—·0472	—·0520	—·0397	—·0320	—·0409	—·0395	—·0297	—·0288	—·0294	—·0377
19	—·0154	—·0217	—·0239	—·0295	—·0337	—·0217	—·0161	—·0244	—·0198	—·0118	—·0152	—·0152	—·0207
20	+·0005	—·0036	—·0015	—·0093	—·0114	—·0003	+·0022	—·0048	+·0004	+·0054	+·0001	+·0004	—·0020
21	+·0113	+·0111	+·0117	+·0070	+·0080	+·0177	+·0180	+·0129	+·0158	+·0171	+·0137	+·0126	+·0131
22	+·0157	+·0198	+·0201	+·0154	+·0191	+·0270	+·0272	+·0244	+·0229	+·0215	+·0205	+·0175	+·0209
23	+·0152	+·0216	+·0190	+·0152	+·0205	+·0258	+·0278	+·0269	+·0217	+·0198	+·0195	+·0141	+·0206

TABLE XIV.—*Mean diurnal epochs of maximum and minimum pressures at Házaribágh.*

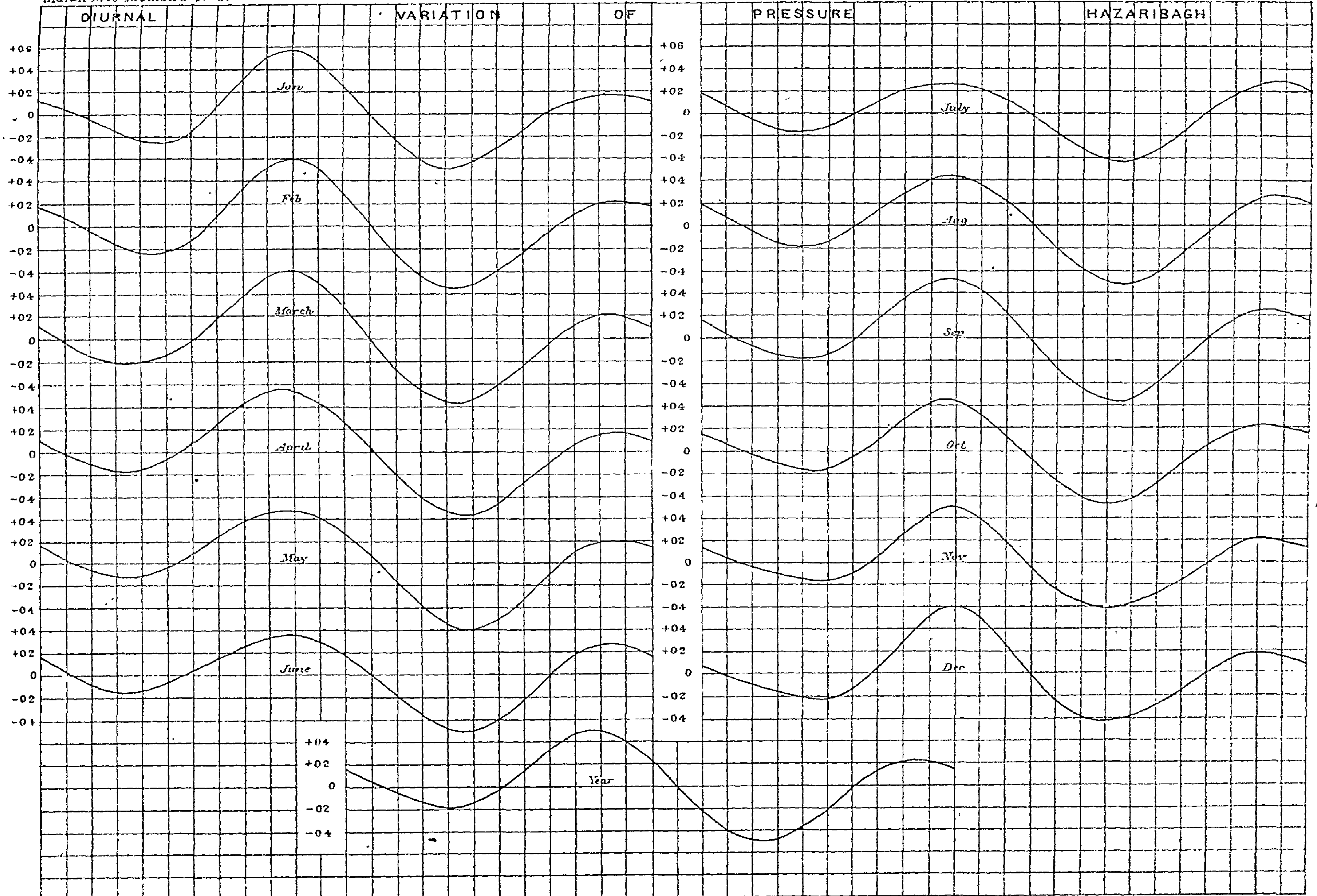
Months.	1st Minimum.		1st Maximum.		2nd Minimum.		2nd Maximum.	
	Hours.	Minutes.	Hours.	Minutes.	Hours.	Minutes.	Hours.	Minutes.
January	4	42	9	51	16	11	22	22
February	4	29	9	58	16	14	22	46
March	3	38	9	50	16	18	22	23
April	3	26	9	31	16	42	22	28
May	3	25	9	40	16	52	22	38
June	3	24	9	45	16	38	22	22
July	3	46	9	35	16	33	22	34
August	3	50	9	47	16	31	22	46
September	3	59	9	40	16	17	22	20
October	4	24	9	34	16	4	22	10
November	4	33	9	53	16	0	22	21
December	4	35	9	55	16	0	22	5
Year	4	2	9	47	16	24	22	27

TABLE XV.—*Mean monthly and annual values of the diurnal maximum and minimum pressures at the above epochs.*

Months.	1st Minimum.	1st Maximum.	2nd Minimum.	2nd Maximum.
January	−·0265	+·0582	−·0478	+·0160
February	−·0242	+·0602	−·0544	+·0217
March	−·0209	+·0617	−·0551	+·0207
April	−·0164	+·0545	−·0569	+·0163
May	−·0126	+·0479	−·0602	+·0211
June	−·0140	+·0360	−·0498	+·0277
July	−·0164	+·0277	−·0420	+·0286
August	−·0183	+·0430	−·0509	+·0271
September	−·0182	+·0527	−·0556	+·0234
October	−·0171	+·0439	−·0471	+·0215
November	−·0179	+·0491	−·0411	+·0210
December	−·0224	+·0604	−·0424	+·0175
Year	−·0179	+·0495	−·0499	+·0217


DIURNAL VARIATION OF PRESSURE CALCUTTA
Jan.
Feb.
March
April
May
June
July.
Aug.
Sep.
Oct.
Nov.
Dec.
Year
+06
+04
+02
0
-02
-04
-06
S. Sedgfield Lith

DIURNAL VARIATION OF PRESSURE HAZARIBAGH



S. Sedgfield lith.

VII.—Variations of rainfall in Northern India, by S. A. Hill, Esq., B. Sc., *Meteorological Reporter to the Government of the North-Western Provinces and Oudh.*

INTRODUCTORY.

The occurrence of the great famine of 1877 in Southern India, and the probability which, up to the 5th of October of that year, seemed a certainty, that a similar fate was in store for Northern and North-Western India, have together caused an extraordinary amount of attention to be directed, both in this country and in Europe, to the subject of the supposed periodical character of those deviations of the rainfall from its normal amount, which produce such calamitous results. Early in 1877, Dr. W. W. Hunter, published a pamphlet entitled "*The Cycle of Drought and Famine in Southern India,*" in which it was shown that there is a remarkable tendency to a deficiency in the rainfall of the city of Madras, at times when the surface of the sun is free from spots,—a phenomenon that had previously been pointed out, though perhaps upon somewhat insufficient evidence, by Mr. J. Norman Lockyer.[1] Dr. Hunter also stated, upon the authority of Sir W. Robinson of the Madras Council, that severe famines and scarcities in various parts of the Southern Presidency also tend to recur at intervals of about eleven years, this being the approximate length of the cycle of the solar maculation. Putting these two classes of facts together, Dr. Hunter concluded (such at least appears from the first edition of his pamphlet) that the rainfall of Southern India is subject to a cyclical variation similar to that of Madras, thus laying himself open to a good deal of not undeserved criticism. Dr. Hunter has since explained that, in the first edition of his pamphlet (printed in India), the words "*Southern India*" were used as a periphrasis to avoid the too frequent repetition of the word *Madras*, to which town and the surrounding district alone his conclusions were intended to apply. See *Nature*, Vol. XVI, page 359.

Mr. H. F. Blanford afterwards discussed the rainfall of seven stations situated in various parts of tropical India, and sent in a short report to the Government of India on the subject, from which it appears that though there is no *evident* relation between rainfall and sun-spot area, yet, by ingeniously combining the observations from the different stations, the amount of precipitation over Southern India can be shown to vary on the average from about five per cent. over the mean, to five per cent. under the mean, at different periods of the eleven-year cycle. These periods do not, however, coincide exactly with the maximum and minimum epochs of the sun-spots. This result is due almost entirely to the great amplitude of the fluctuation of the Madras rainfall, since only one other station out of the seven, Nagpur, exhibits any decided tendency to vary concomitantly with Madras. About the same time, the writer of the present paper

[1] *Nature*, vol. VII, p. 98, and Lockyer's *Solar Physics*, Chap. XXVI.

submitted to the North-Western Provinces Government the results of a discussion of the rainfall registers—most of them for very short periods—of several stations in Northern India. These registers seemed to lend some support to the theory that, underlying very great irregular and non-periodic variations, there is a fluctuation of the total annual rainfall coinciding approximately with that of sun-spot frequency; but, by themselves, they were incapable of proving any such conclusion, since they were much too short to admit of the elimination of chance coincidences. Another inference, drawn from the discussion of the same records, was that the winter rains of Northern India are generally heavier when the total fall of the year is below the mean, than when the summer rains are excessive. A similar result had also at this time been independently obtained by Mr. E. D. Archibald from a discussion of the winter rainfall of the single station, Calcutta.[1] It is obvious that, if the latter inference will stand the test of a fuller and more extended inquiry, it may be of very great economic importance, as the experience of the last two years clearly shows. In 1876 there was a partial, and in 1877 almost a total, failure of the summer rains over the greater part of the North-Western Provinces, Oudh, Rajputana, and the Panjab; but in both years there was a heavy fall of rain in October, which enabled the winter crops to be sown, followed by copious downpours in January and February in the former case, and in December and January in the latter; the effect being in both cases the production of an unusually good *rabi* harvest.[2]

For the purpose of testing the soundness of this conclusion, and also of inquiring into the truth of the supposed cyclical variation of the annual rainfall, I have examined all the available rainfall registers for the North-Western Provinces and Oudh, together with a large number of others that have been placed at my disposal by the courtesy of the Meteorological Reporter to the Government of India, and of the Secretary to the Financial Commissioner of the Panjab.

From these I have selected for further discussion the registers of twenty representative stations, including all those which extend over a period of twenty or more consecutive years, together with several others chosen on the principle of embracing as great a geographical area as possible, in order that the minor irregularities depending upon the local peculiarities of any one station may be neutralised as far as possible by those of some other. The country included between these stations extends from Sibsagar in Eastern Assam to Bannu on the north-west frontier, and from Jabalpur in the Central Provinces to Abbottabad in the Hazara country, thus covering more than eleven degrees of latitude and twenty-four degrees of longitude. For convenience in drawing up some of the following tables, the stations have been divided into two groups, ten in or near the Himalayas and their subordinate mountain chains, and ten on the plains. The rainfall for the four years, 1861, 1862, 1867, and 1868, has been added to the Sibsagar register from that of the adjacent station Nazirah; and the Monghyr register has been extended back from 1848 to 1843 by means of observations taken at Patna. The winter falls of these two stations are almost identical, but the summer fall is less at Patna than at Monghyr by about 10 per cent.

[1] See *Nature*, Vol. XVI, p. 339.

[2] Since the above was written, I have learnt that the outturn of the *rabi* in most districts of the North-Western Provinces in 1878 has been less than was expected, owing to hail, blight, and hot winds in the beginning of March.

The winter and summer rainfalls of each station have been tabulated separately as in the appendix; under the latter name is included the rain which fell during the months of May, June, July, August, September and October in each year, and under the former the rainfall of the remaining months.

The figures in the tables vary much from year to year, but any very great deviations from the mean are comparatively infrequent. Thus, in the table for Calcutta, which is the longest we have, the winter rains exhibit distinct minima in 1829, 1840, 1853, 1860 and 1873. The successive intervals from minimum to minimum were thus 11, 13, 7, and 13 years, giving a mean of eleven years. The maxima of the winter rains do not recur so regularly as even this; and the summer rains are very irregular, decided minima occurring in 1832, 1837, 1845, 1853, 1860, 1865, 1869, 1873 and 1877. These dates give a mean interval of only 5·6 years. The winter rains at Jabalpur reached their minima in 1848, 1860, 1869 and 1876, the mean length of the cycle being thus apparently 9·6 years, while the summer rains fluctuate more frequently, and exhibit an average period of only 5·5 years. Three other registers, those of Ambala, Shahpur and Gujranwala, extend over more than twenty years, and these show apparent average cycles for the winter rains of 10, 11, and 8·5 years, and for the summer rains of 11, 9, and 10 years, respectively. On the hypothesis that there is a periodical variation of the rainfall, notwithstanding the great inequalities of the intervals from minimum to minimum, or from maximum to maximum, the length of the period would appear to be ten or eleven years, the shorter intervals exhibited by the fluctuations of the summer rains of Calcutta and Jabalpur being, according to the hypothesis, either fortuitous, or the result of a secondary oscillation of half the period, accompanying the other. The eleven-year cycle is to be preferred to one of 10, 9, or 8·5 years, for the reason that it represents best the variation of the winter rains at Calcutta, the station with the longest and most trustworthy register, as well as on the ground that the amount of precipitation at many widely distant places on the earth's surface has already been found by Mr. Meldrum to follow a cycle of this period.[1] For the present, therefore, it will be assumed that there is a periodic variation of the rainfall, repeating itself every eleven years, and I shall now proceed to inquire how far the observations from year to year accord with, or are opposed to, the supposition. The results of the inquiry will at the same time serve to show whether the rainfall variations of Northern India support, or are opposed to, Mr. Meldrum's hypothesis, that rain is more abundant when sun-spots are numerous, since the two cycles are supposed to be of equal length.

Summer Rainfall.

When the summer rainfall for each station is arranged in eleven-year series, and the average rainfall for each year of the supposed cycle is calculated, we get the results embodied in Table I, A. and B. The number of years on which the average is founded is given in the first sub-division of each double column. The groups of years including 1860 and 1870 represent the maxima of sunspots, and the groups containing 1866 and 1867, the minima.

[1] The latest results of Mr. Meldrum's researches regarding this question are published in the *Mauritius Almanac and Colonial Register for 1878.*

TABLE I—A.

Average Summer Rainfall at Himalayan and Sub-Himalayan stations, for each year of the Cycle.

Year	Bannu.		Peshawar		Abbottabad		Rawalpindi		Dharmsala		Simla.		Dehra		Naini Tal		Darjiling		Sibsagar	
	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches
1860, &c	1	7 00	1	3 70	1	31 70	1	21 10	1	175 50	1	70 20	1	102 70	1	81 50	2	112 62	2	77 62
1861, &c.	1	4 70	1	10 00	1	47 90	1	18 00	1	141 70	1	54 30	2	83 10	1	102 00	2	123 53	3	66 96
1862, &c	2	6 45	2	4 15	2	23 40	2	21 40	2	123 15	3	60 00	2	74 90	2	80 40	2	91 27	3	63 04
1863, &c	2	17 50	2	6·75	2	27 20	2	30 10	2	131 90	2	53 15	2	81 95	2	71 95	1	116 15	2	92 58
1864, &c	2	8 55	2	7 35	2	32 90	2	33 75	2	101 65	2	73 15	2	60 90	2	60 85	1	108 06	2	83 55
1865, &c	2	6 75	2	5 40	2	29 70	2	18 80	2	103·70	2	61 90	2	70 95	2	67 25	1	113 18	2	58 33
1866, &c	2	7 10	2	1 80	2	24 30	2	13 30	2	69 55	2	47 85	2	44 85	2	50 90	1	91 57	2	66 90
1867, &c	1	11·10	1	3 90	1	30 60	1	12 80	1	157 80	1	45 80	1	62 70	1	88 60		.	1	72 77
1868, &c	1	3 90	1	1 90	1	17 50	1	14 80	1	78 40	1	49 50	1	41 70	1	71 90	1	128 93	1	62 73
1869, &c	1	6 50	1	10 30	1	24 90	1	10 40	1	103 90	1	45 90	1	70 50	1	62 60	1	93 18	1	84 30
1870, &c	1	4 80	1	4 30	1	24 70	1	27 70	1	158 40	1	53 00	1	77 50	1	98 70	2	125 90	1	87 65
Local means	16	8 17	16	5 31	16	28 27	16	21 22	16	117 22	17	57 11	17	69 91	16	73 00	14	111 26	20	72 77

TABLE I—B.

Average Summer Rainfall at stations on the Plains, for each year of the Cycle.

Year.	Calcutta		Monghyr		Benares		Allahabad		Jabalpur		Delhi		Ambala		Lahore		Gujranwala		Shahpur	
	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches	Years	Inches
1860, &c	4	61 37	3	35 65	2	37 71	1	57 40	3	49 73	3	30 48	2	31 55	1	6 30	2	12 20	2	9 35
1861, &c	4	61 77	3	44 03	2	44 04	2	39 15	3	49 67	2	26 65	2	38 65	1	14 00	2	22 20	2	16 40
1862, &c	5	56 48	3	37 55	3	36 82	2	40 85	3	39 81	2	41 70	2	37 50	2	20 65	2	23 55	2	16 95
1863, &c	5	58 17	2	47 02	2	55 47	2	35 45	3	72 34	2	26 70	3	42 37	2	17 25	2	18 75	2	12 75
1864, &c	5	60 09	2	43 04	2	30 68	2	33 28	3	50 50	2	30 30	3	27 37	2	20·30	2	30 40	2	7 70
1865, &c	5	56 26	3	35 58	2	29 09	2	31 91	3	52 52	2	22 00	3	33 93	2	18 05	3	21 67	2	10·55
1866, &c	5	59 80	3	36 66	3	30 03	2	19 27	4	43 83	3	19 23	3	18 37	2	10 45	3	17 30	3	8 57
1867, &c	4	60 07	1	31 21	2	43 31	1	47 00	3	51 11	2	20 10	2	38 85	1	16 80	2	23 25	2	14 65
1868, &c	4	74 85	2	33 30	2	34 04	1	24 00	3	43 97	2	12 04	2	19 10	1	7 30	2	14 00	2	7 75
1869, &c	4	54 49	2	40 10	2	40 40	1	45 30	3	48 60	2	22 65	2	27 10	1	15 90	2	20 65	2	9 85
1870, &c	4	53 55	2	53 35	2	54 86	1	52 70	3	52 31	3	20 55	2	26 00	1	8 20	2	16 00	2	7 25
Local means	49	59 83	26	39 74	24	39 58	17	36 84	34	50 21	25	24 60	26	30 91	16	16 12	24	19 95	23	10·96

Taking these numbers year by year, we find that the maximum rainfall occurred in the first year of the cycle at Dharmsala, Dehra and Allahabad; in the second year, at Abbottabad and Naini Tal; in the third, at Delhi, Lahore and Shahpur; in the fourth, at Bannu, Ambala and Jabalpur; in the fifth, at Rawal Pindi, Simla and Gujranwala; in

the ninth, at Calcutta and Darjiling; in the tenth, at Peshawar, and in the eleventh, at Sibsagar, Monghyr and Benares. The minimum rainfall of the cycle occurred in the first year at Lahore and Gujranwala; in the third year, at Darjiling and Jabalpur; in the sixth, at Sibsagar and Benares; in the seventh, at Dharmsala, Naini Tal, Allahabad and Ambala; in the eighth, at Simla and Monghyr; in the ninth, at Abbotabad, Dehra, Bannu, Peshawar and Delhi; in the tenth, at Rawal Pindi, and in the eleventh, at Calcutta and Shahpur. As regards the supposed direct variation of the summer rainfall with the sunspots, these twenty stations might therefore be divided into three groups, eight favourable to the hypothesis, namely, Abbottabad, Dharmsala, Dehra, Naini Tal, Sibsagar, Monghyr, Benares and Allahabad; seven unfavourable to it, namely, Rawal Pindi, Darjiling, Calcutta, Jabalpur, Lahore, Gujranwala and Shahpur, and five neutral, namely, Simla, Bannu, Delhi, Ambala and Peshawur.

With the exception of Calcutta and Jabalpur, the stations unfavourable to the hypothesis all lie on the borders of the monsoon region, and this circumstance, as I will endeavour to show further on, may possibly serve to explain the apparently opposite character of the evidence given by two sets of stations as nearly as possible equal in number. The registers of the favourable stations, half of which are situated in the North-Western Provinces, and one other, Monghyr, in the adjacent Province of Behar, are all too short to allow us to see whether the cycle repeats itself; as it should do if it be not merely fortuitous. It may therefore be considered superfluous to follow the discussion of the summer rains any farther; but for the sake of a more perfect comparison of the summer with the winter rainfall, I have, in Table II, calculated the numbers given in Table I as percentage variations from the local means. The means given at the foot of the table are calculated on the principle of allowing each station a weight proportionate to the number of years which have contributed to form the average on which the percentage variation given in any vertical column, opposite the name of the station, is founded.

TABLE II.

Variation of the Summer Rainfall for each year of the Cycle in Percentages of the Local Means.

Stations.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.
Bannu	−14·3	−42·5	−21·1	+114·2	+ 4·6	−17·4	−13·1	+35·9	−52·3	−20·4	−41·2
Peshawar	−30·3	+88·3	−21·8	+ 27·1	+38·4	+ 1·7	−66·1	−26·6	−64·2	+91·0	−19·0
Abbottabad ...	+12·1	+69·4	−17·2	− 3·8	+16·4	+ 5·1	−14·0	+ 8·2	−38·1	−11·9	−12·3
Rawal Pindi ...	− 0·6	−15·2	+ 0·8	+ 41·8	+59·0	−11·8	−37·3	−39·7	−30·2	−51·0	+30·5
Dharmsala	+49·6	+20·9	+ 5·1	+ 12·5	−13·3	−11·5	−40·8	+34·6	−33·1	−11·3	+35·9
Simla	+22·9	− 4·9	+ 5·1	− 6·9	+28·1	+ 8·4	−16·2	−19·8	−13·3	−19·6	− 7·2
Dehra	+47·0	+18·9	+ 7·1	+ 17·2	−12·9	+ 1·5	−35·8	−10·3	−40·4	+ 0·8	+10·8
Naini Tal	+11·7	+39·7	+10·1	− 1·4	−16·7	− 7·9	−30·3	+21·4	− 1·5	−14·2	+35·2
Darjiling	+ 1·2	+11·0	−17·9	+ 4·4	− 2·9	+ 1·7	−17·7	...	+15·9	−16·2	+13·1
Sibsagar	+ 6·7	− 8·0	−13·4	+ 27·2	+14·8	−19 9	− 8·1	0 0	−13·8	+15·8	+20·4
Mean for Himalayan Stations	+ 7·6	+13·8	− 6·1	+ 24·2	+ 12	− 5·4	−28·5	+ 0·4	−27·1	− 3·4	+ 7·2

Variation of the Summer Rainfall for each year of the Cycle in Percentages of the Local Means—concluded.

Stations.	1st	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th	10th.	11th
Calcutta	+ 2·5	+ 8·3	− 5·6	− 2·3	+ 0·4	− 5·9	0·0	+ 0·4	+25·1	− 8·9	−10·5
Monghyr	−10·3	+10·8	− 5·5	+18·3	+ 8·3	−10·5	− 7·7	−21·5	−16·2	+ 0·9	+34·2
Benares	− 4·7	+11·3	− 7·0	+40·1	−22·5	−26·5	−24·0	+ 9·4	−14·0	+ 2·0	+38·6
Allahabad	+55·8	+ 6·3	+10·9	− 3·8	− 9·7	−13·3	−47·7	+27·6	−34·8	+23·0	+43·0
Jabalpur	− 0·9	− 1·1	−20·7	+14·1	+ 0·6	+ 4·6	−12·7	+ 1·8	−12·4	− 3·2	+ 4·2
Delhi	+23·9	+ 8·3	+69·5	+ 8·5	+23·2	−10·6	−21·8	−18·3	−51·1	− 7·9	−16·5
Ambala	+ 2·1	+25·0	+21·3	+37·0	−11·5	+ 9·8	−40·6	+25·7	−38·2	−12·3	−15·9
Lahore	−58·3	− 7·4	+36·6	+14·1	+34·3	+19·4	−30·9	+11·1	−51·7	+ 5·2	−45·8
Gujranwala .	−38·8	+11·3	+18·0	− 6·0	+52·4	+ 8·6	−13·3	+16·5	−29·8	− 3·5	−19·8
Shahpur ...	−14·7	+49·6	+54·6	+16·3	−29·7	− 3·7	−21·8	+33·6	−29·3	−10·1	−33·8
Mean for Plains Stations	− 2·9	+12·1	+11·3	+16·3	+ 3·3	− 2·3	−19·2	+ 7·9	−18·1	− 3·8	− 3·4
General mean	+ 0·8	+12·7	+ 3·3	+19·8	+ 7·4	− 3·5	−22·7	+ 5·6	−21·0	− 3·6	+ 0·2

The final result is very irregular, since there are no less than three maxima within the eleven years, in the 2nd, 4th and 8th years respectively, and three corresponding minima in the 3rd, 7th and 9th years. After reducing the chief accidental or unperiodic variations by adding to the number for each year half the sum of those for the preceding and succeeding years, and dividing the sum by two, we get the following series of numbers, which has been plotted out graphically in figure 6 of the plate at the end of this paper.

Years of the cycle ...	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.
Corrected mean variations	+3·6,	+7·4,	+9·8,	+12·6,	+7·8,	−5·6,	−10·8,	−8·1,	−10·0,	−7·0,	−0·6.

This result accords fairly with the assumption that there is an eleven-year cycle of rainfall, and it is very similar to that obtained by Mr. Blanford from a discussion of the annual rainfalls of seven stations in Southern India, two of which, Calcutta and Jabalpur, are, however, included in the table given above. In both cases the maximum is reached in the fourth year of the cycle, and the minimum follows it closely, occurring in the sixth year in Southern India, and in the seventh in Northern India; in both cases also there is a tendency towards a second maximum in the eighth year, that in which the sunspots reach their minimum. Neither Mr. Blanford's result nor this can, therefore, be said to lend unequivocal support to Mr. Meldrum's hypothesis; for the character of the oscillation in the case of the rainfall is very different from that of the sunspots; the fall from maximum to minimum occurring in three years, and the rise from minimum to maximum occupying eight; whereas in the average sunspot cyle, represented in figure 5, the fall occupies seven years and the rise only four. The range of the oscillation appears to be more than twice as great at these northern stations as it is in the south.

Were the total annual rainfall thus dealt with, it would, doubtless, display an equal, if not greater, amount of irregularity, since the winter fall at all the stations except those of the north-west Panjab is an inconsiderable fraction of the whole, and, as I shall now proceed to show, it seems to vary inversely with the summer rain.

Winter Rainfall.

On treating the figures for the winter rainfall in a similar way, we find evidence of much greater regularity. Table III gives the average winter rain of each station for each year of the cycle, together with the number of years on which the average is founded.

TABLE III—A.

Average Winter Rainfall at Himalayan and Sub-Himalayan Stations, for each year of the Cycle.

Year.	Bannu.		Peshawar.		Abbottabad.		Rawul Pindi.		Dharmsala.		Simla.		Dehra.		Naini Tal.		Darjiling.		Sibsagar.	
	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.
1860, &c.	1	3·30	1	7·50	1	18·40	1	7·40	1	18·90	1	3·70	1	3·90	1	15·00	2	5·93	2	21·57
1861, &c.	1	5·10	1	6·40	1	21·90	1	12·30	1	16·70	1	7·90	2	6·70	2	7·00	2	5·32	3	21·63
1862, &c.	1	2·90	1	6·30	1	11·40	1	6·10	1	13·50	2	6·35	2	6·20	1	7·40	3	8·91	3	16·55
1863, &c.	2	3·75	2	6·05	2	14·15	2	9·30	2	18·95	2	8·45	2	7·30	2	8·30	1	8·85	2	20·04
1864, &c.	2	6·05	2	8·20	2	20·65	2	10·10	2	20·20	2	13·85	2	5·90	2	5·95	1	7·11	2	28·94
1865, &c.	2	5·65	2	11·25	2	22·95	2	13·35	2	25·35	2	15·60	2	10·45	2	16·70	1	3·45	2	21·48
1866, &c.	2	10·00	2	16·85	2	28·00	2	18·55	2	27·85	2	18·95	2	11·25	2	20·80	1	11·74	2	15·49
1867, &c.	1	5·20	1	2·00	1	18·50	1	8·50	1	16·00	1	6·30	1	4·70	1	8·10	...	...	1	16·93
1868, &c.	1	14·40	1	10·70	1	27·30	1	8·60	1	31·10	1	11·80	1	11·40	1	17·50	1	6·41	1	26·27
1869, &c.	1	5·30	1	6·20	1	25·60	1	17·40	1	30·70	1	12·10	1	11·90	1	16·00	1	7·40	1	19·00
1870, &c.	1	1·40	1	3·90	1	8·30	1	2·30	1	20·10	1	16·20	1	7·60	1	7·50	2	8·59	1	10·96
Local means...	15	5·90	15	8·51	15	20·19	15	11·01	15	22·11	16	11·52	17	7·95	16	11·81	15	7·42	20	20·44

TABLE III—B.

Average Winter Rainfall at Stations on the Plains for each year of the Cycle.

Year.	Calcutta.		Monghyr.		Benares.		Allahabad.		Jabalpur.		Delhi.		Ambala.		Lahore.		Gujranwala.		Shahpur.	
	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.	Years.	Inches.
1860, &c.	4	5·98	3	1·25	2	2·25	1	1·50	3	1·76	3	3·30	2	4·25	1	2·40	2	2·55	2	2·05
1861, &c.	4	5·60	3	2·20	2	2·26	1	3·50	3	2·60	3	3·12	2	2·95	1	3·10	2	5·05	2	3·65
1862, &c.	5	3·97	3	1·74	3	2·18	2	1·25	3	1·44	3	2·55	2	2·25	1	1·30	2	2·45	2	3·50
1863, &c.	5	7·05	3	1·83	2	0·47	2	0·28	3	1·80	2	2·85	2	3·85	2	3·55	2	5·10	2	2·75
1864, &c.	5	5·76	2	1·17	2	1·43	2	0·49	3	1·79	2	2·65	3	3·30	2	2·50	2	3·25	2	3·60
1865, &c.	5	8·41	3	2·06	2	1·24	2	2·00	3	4·10	2	2·30	3	5·90	2	4·70	2	8·25	2	7·20
1866, &c.	5	6·51	3	3·63	3	2·41	2	3·48	3	5·81	2	5·30	3	10·97	2	6·65	3	10·13	2	8·15
1867, &c.	4	6·58	1	2·07	2	3·33	1	2·60	3	2·88	2	3·24	2	0·95	1	3·30	2	2·75	2	4·60
1868, &c.	4	5·75	2	2·21	2	1·06	1	0·80	3	2·17	2	2·47	2	8·05	1	7·80	2	8·00	2	7·55
1869, &c.	4	5·46	2	2·38	2	1·60	1	0·30	3	0·32	2	3·43	2	6·00	1	4·00	2	4·85	2	5·95
1870, &c.	4	4·25	2	0·68	1	0·93	1	0·90	3	1·66	2	1·99	2	7·10	1	1·00	2	4·40	2	4·05
Local means...	49	5·96	27	1·97	23	1·84	16	1·51	33	2·39	25	3·01	25	5·25	15	3·85	23	5·38	22	4·82

From this it appears that the maximum does not occur in the 1st, 3rd, 4th or 11th year of the cycle at any station; that it occurs in the 2nd at one station only, Allahabad; but that the rainfall given in the table for the 7th year at that station is almost as great, and represents an average of two years instead of the fall of a single year; that the maximum is reached at one station, Sibsagar, in the 5th, and at one, Calcutta, in the 6th year; that it occurs at no less than thirteen out of the twenty stations, in the 7th year; at one, Benares, in the 8th; at two, Bannu and Dharmsala, in the 9th, and at one, Dehra, in the 10th. The minimum amount of precipitation in winter occurs in the 1st year at four stations, in the 3rd at two, in the 4th at two, in the 5th at one, in the 6th at one, in the 8th at two, in the 10th at one, and in the 11th at seven stations.

The driest years of the cycle thus appear to be the 1st and the 11th, and the wettest year, the 7th. In fact, if we divide the cycle into a group of many sunspots, including the 11th, 1st, 2nd, 3rd and 4th years, and a group of few sunspots, including the remaining years, fourteen out of the twenty stations support the hypothesis that the winter rainfall varies *inversely* with the sunspots, none are opposed to it, and six may be classed as neutral, that is, they support the hypothesis as regards one epoch, either the maximum or the minimum, and are opposed to it as regards the other. These stations are Peshawar, Naini Tal, Darjiling, Jabalpur and Ambala, with the maximum favourable and the minimum unfavourable to the hypothesis, and Allahabad, with the maximum unfavourable and the minimum favourable to it.

When Table III is thrown into the form of percentage variations from the local mean for each station, we get the results exhibited in Table IV.

TABLE IV.

Variation of the Winter Rainfall for each year of the Cycle, in Percentages of the Local Means.

Stations.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.
Bannu	−44·1	− 13·6	−50·8	−36·4	+ 2·5	− 4·2	+ 69·5	−11·9	+144·1	−10·2	−76·3
Peshawar	−11·9	− 24·8	−26·9	−28·9	− 3·6	+32·2	+ 98·0	−76·5	+ 25·7	−27·1	−54·2
Abbottabad... ..	− 8·8	+ 8·5	−43·5	−29·9	+ 2·3	+13·7	+ 38·7	− 8·4	+ 35·2	+26·8	−58·9
Rawal Pindi ...	−32·7	+ 11·7	−44·6	−15·5	− 8·2	+21·2	+ 68·5	−22·8	− 21·9	+58·0	−79·1
Dharmsala	−14·5	− 21·5	−38·9	−14·5	− 8·6	+14·7	+ 25·9	−27·6	+ 40·7	+38·8	− 9·1
Simla	−67·9	− 34·1	−44·9	−26·6	+20·2	+35·4	+ 64·5	−45·3	+ 2·4	+ 5·0	+40·6
Dehra	−50·9	− 15·7	−22·0	− 8·2	−25·8	+31·4	+ 41·5	−40·9	+ 43·4	+49·7	− 4·4
Naini Tal	+26·2	− 40·7	−37·3	−29·7	−49·6	+41·4	+ 76·1	−31·4	+ 48·2	+35·5	−36·5
Darjiling	−20·1	− 28·3	+20·1	+19·3	− 4·2	−53·5	+ 58·2	...	− 13·6	− 0·3	+15·8
Sibsagar	+20·2	+ 5·8	−19·0	− 1·9	+41·5	+ 5·1	− 24·2	−17·1	+ 28·5	− 7·0	− 4·6
Mean for Himalayan Stations	−17·0	− 15·3	−23·3	−19·2	− 3·4	+17·3	+ 51·3	−31·2	+ 33·3	+21·4	−22·8

Variation of the Winter Rainfall for each year of the Cycle, in Percentages of the Local Means—concluded.

Stations.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.
Calcutta	+ 0·3	− 6·0	−33·4	+18·3	− 3·1	+41·1	+ 9·2	+10·1	− 3·5	− 8·4	−28·6
Monghyr	−36·5	+ 11·7	−11·7	− 7·1	−40·6	+ 4·6	+ 81·3	+ 5·1	+ 12·2	+20·8	−65·5
Benares	+22·3	+ 22·8	+15·8	−74·5	−22·3	−32·6	+ 31·0	+81·0	− 42·4	− 2·2	−49·4
Allahabad	− 2·6	+127·3	−18·8	−81·8	−68·2	+29·9	+126·0	+68·8	− 48·0	−80·5	−41·6
Jabalpur	−26·3	+ 8·8	−39 7	−21·7	−25·1	+71·5	+143·1	+20·5	− 9·2	−86·6	−30 5
Delhi	+ 9·6	+ 3·6	−15·3	− 5·3	−10·3	−23·5	+ 76·1	+ 4·3	− 17·9	+14·0	−33·9
Ambala	−19·0	− 43·8	−57·1	−28·6	−37·1	+12·4	+108·9	−81·9	+ 53·3	+14·3	+35·2
Lahore	−37·7	− 19·2	−66·2	− 7·8	−35·1	+22·1	+ 72·7	−14·3	+102·6	+ 3·9	−74·0
Gujranwala ...	−52·6	− 6·1	−54·5	− 5·2	−39·6	+53·3	+ 88·3	−48·9	+ 48·7	− 9·8	−18·2
Shahpur	−57·5	− 24·3	−27·4	−42·9	−25·3	+49·3	+ 69·1	−45·6	+ 56·6	+23·4	−15·9
Mean for Plains Stations	−17·9	+ 2·3	−27·0	−19·8	−27·5	+25·7	+ 75·0	− 1·0	+ 11·1	+11·9	−28·4
General mean ...	−17·6	− 4·6	−25·6	−19·5	−17·0	+22·1	+ 65·4	−10·4	+ 18·3	+14·9	−28·6

It is evident from this, that the 3rd, 4th and 11th are the driest years of the cycle; the rainfall at every station but two being below the average in each of the former years, and of every station except three in the latter. On the other hand, the rainfall was excessive at all the stations except four in the 6th year, and in the 7th the excess was very great at every station but one. By combining these, due allowance being made for differences in the number of years which contribute to the average in each case, we get the general mean given at the foot of the table. This shows that the winter rainfall is defective in the 11th, 1st, 2nd, 3rd, 4th and 5th years of the cycle; and excessive in the 6th, 7th, 9th and 10th years. There is a secondary minimum in the 8th year, due chiefly to the influence of the hill stations, in the registers of which that part of the cycle is represented by the single year 1867.[1] Distributing the greater irregularities by the process given above for the summer rains, we get the following values for the mean annual variation :—

Years of the cycle	1st.	2nd.	3rd,	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.
Variation ...	−17·1,	−13·6,	−18·8,	−20·4,	−7·8,	+23·1,	+35·6,	+15·7,	+10·2,	+4·9,	−14·9

These numbers, when plotted out as in figure 7, give a curve the lowest point of which lies between the 3rd and 4th years, and the highest between the 6th and 7th, thus almost exactly representing the inverse of the curve for the summer rain.

The form of this curve may, however, be determined almost entirely by the rainfall of the last decade, for more than half of the registers under discussion are less than

[1] This secondary minimum would disappear if the winter rainfall of 1878, which has been unusually heavy, were included in the table.

twenty years in length, and we know the year 1877 was everywhere characterised by an excessive amount of rainfall in the earlier months, while in 1873 the winter and spring rains failed over the greater part of Northern India. In order to prove that the result is other than fortuitous, it is necessary to inquire whether, in the more extended registers, we can find any appearance of a repetition of the cycle. If the cycle should prove to have been repeated several times in succession, the probability of its being merely accidental will become so very small as to be quite inappreciable.

On referring to the tables in the appendix, we find that, if we count back from 1877, the Calcutta register includes four complete cycles, 1834-77; the Jabalpur register covers three cycles, 1845-77; the registers of Ambala, Shahpur and Gujranwala each include twenty-two years, 1856-77, and those of twelve other stations show a continuous record for the last eleven years. By converting the winter fall of each year into a percentage variation from the local mean, and taking the average of these for each of the four cycles separately, we get the following table:—

TABLE V.

Percentage Variations of the Winter Rainfall from the mean during the years of each Cycle.

Cycle.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th year.
1st, 1834-44 (1 Station)	−27·0	+11·4	−56·8	−62·0	−67·9	−28·6	−79·1	−14·2	+41·6	+ 13·9	− 38·8
2nd, 1845-55 (2 Stations)	+56·8	−18·8	−20·3	−79·4	+32·3	−15·6	− 9·2	+64·8	−59·4	+125·8	+ 87·8
3rd, 1856-66 (5 Stations)	−29·0	−14·6	−51·2	+12·2	−57·0	−11·0	−23·3	−29·6	− 2·2	+ 99·2	+ 6·7
4th, 1867-77 (17 Stations)	−20·3	+53·2	+11·2	−28·0	−13·8	+ 4·9	−48·2	−24·5	−26·3	− 40·1	+169·5

This table, notwithstanding many apparently anomalous oscillations, exhibits a considerable degree of uniformity as regards the epochs of maximum and minimum in each cycle. The years of maximum rainfall of the four cycles were 1842, 1854, 1865 and 1877, giving intervals of twelve, eleven, and twelve years; and the minimum years were 1838 or 1840, 1848, 1860 and 1873, that is, the minimum recurred at intervals of eight or ten, twelve and thirteen years. These dates may be readily verified by referring to the zig-zag line in figure 2, where the numbers in Table V have been plotted out. The upper curve, figure 1, is plotted from Wolf's relative sunspot numbers inverted. The years of sunspot minima, as given by Wolf, were 1843, 1856, 1867 and (probably) 1877, and those of sunspot maxima, 1837, 1848, 1860 and 1870. The maximum of winter rainfall would therefore appear to be reached on the average rather more than a year *before* the minimum of sunspots, and the minimum rainfall appears either to coincide with or to follow the maximum of the sun-spots at about an equal interval. The two phenomena cannot, therefore, be directly related to each other as cause and effect, though they may both be the effects of a common cause.

The regular repetition of the oscillation above and below the mean is more clearly seen when the irregularities of the zig-zag line are rounded off by the process above described, that of taking triennial means in which the middle year is allowed double

weight. The annual variation, when modified in this way and plotted out, gives the thick curved line of figure 2.

OTHER METEOROLOGICAL ELEMENTS.

Immediately below the curve of winter rainfall is drawn another (figure 3) representing the variation of the annual mean temperature in the tropics, corrected in the same way as the rainfall variation by taking triennial means.[1] From 1834 to 1862, this is simply a reproduction of the curve given by Köppen in the *Journal of the Austrian Meteorological Society*, Vol. VIII, No. 17, deduced from observations taken in the Dutch East Indies, on the continent of India and in tropical America. The remainder of the curve has been drawn from the results of Indian observations alone, and unfortunately the longest temperature registers at hand did not belong to exactly the same stations as those on Köppen's list.[2] In consequence of this, the continuation of the curve from 1863 onwards is of somewhat doubtful accuracy, and, in drawing any conclusions, this portion should only be allowed one-third or one-fourth of the weight assigned to the first part. Were it corrected by observations from other tropical countries, it is probable that some of the minor oscillations in the latter part of the curve would disappear. Nevertheless, the coincidence of the two curves, representing tropical temperature and winter rainfall, is sufficiently striking to incline one to think that the two phenomena must either be related to each other as cause and effect, or at least the effects of a common cause. This would, of course, be an unsafe conclusion to draw from the present evidence alone; but if curves derived from the rainfall of other countries besides India, and from the temperature observations of other tropical countries, were to show an equal degree of similiarity, the conclusion could hardly be resisted that there is a causal connection between the two phenomena.

What the order of this connection is, will probably be indicated by the order in which the two phenomena reach their maxima and minima. The following table gives the approximate epoch of maximum and minimum of the two, as calculated by the method of differences from the elements of the curves. The figures printed in italics are founded upon Indian observations alone, and are not so trustworthy as the others, which are calculated from Köppen's data.[3]

TABLE VI.

Maximum and Minimum epochs of tropical temperatvre and winter rain.

Minima.		Maxima.	
Temperature.	Rainfall.	Temperature.	Rainfall.
1836·9[4]	1837·8	1842·7	1842·7
1847·7	1848·1	1854·7	1855·0
1858·4	1860·6	*1865·1*	1865·5
1874·8	1874·7	(*1876·3*)	(1876·9)

[1] The corrected value given for the last year in each of the curves is the simple mean of 1876 and 1877.

[2] Köppen employed the registers of Calcutta, Madras, Bombay and Kathmandu. The continuation of the curve is obtained from the registers of Calcutta, 1863-76; Bombay, 1863-69 and 1875-77; Vizagapatam, 1870-77; Roorkee, 1863-77 and Agra 1863 and 1865-77.

[3] It is perhaps hardly necessary to state that Professor Piazzi Smyth, Mr. E. J. Stone, Dr. F. G. Hahn, and others, have independently discovered the eleven-year cycle of temperature.

[4] At the beginning of the year the decimal = 0.

From the four epochs of minimum given in the table it appears that the least winter rain follows the lowest annual temperature at an average interval of 9-10ths of a year, and from the three maximum epochs[1], that the heaviest rainfall follows the highest temperature at an average interval of one-fifth of a year. So far as the data warrant the drawing of any conclusion, therefore, it appears most probable that the variation of tropical temperature is the cause, and that of the rainfall the effect. From the above table it also appears that the winter rain is generally most abundant about a year before the minimum of sunspots, while the minimum rainfall occurs sometimes a little before, and sometimes a little after the sunspot maximum, as has been stated on a previous page. I do not, of course, mean to assert that the temperature variations here indicated are sufficient to account for the observed variations of rainfall, but only that they must be counted as one, and not an unimportant one, of the causes of these changes in the amount of precipitation; and it is, I believe, not opposed to any of the known laws of physics to assume that variations of solar activity must affect rainfall chiefly through the medium of terrestrial temperature, or, to speak more exactly, of the temperature of tropical seas and of the air over them.

I have elsewhere shown[2] that the known laws of the winds render it probable that a higher temperature than usual in the tropical parts of the ocean will be accompanied by an increase of the rainfall of temperate regions, since the upper current, known as the *antitrade*, will probably, under such conditions, blow more strongly than usual, and, at the same time, be supplied with a greater abundance of aqueous vapour, owing to the high temperature of the ocean over which it rises. This view is strongly supported by the law which has been clearly established by the labours of Meldrum and Poëy, that the cyclones of tropical seas are most frequent in cool years, or, as Meldrum says, in years of maximum sunspot. The condensation theory of the origin of these storms which has been steadily gaining ground for many years, until now—as regards the Bay of Bengal at least—its truth may almost be taken as demonstrated, assumes that the source of the energy of the storm is the latent heat given out by the condensation of water vapour over the place of evaporation.[3] The conditions that give rise to this are a nearly uniform barometric pressure with light winds or calms over the area in which the cyclone is generated, and these conditions obviously imply that the usual atmospheric currents by which the vapour is generally removed as fast as it is formed, must be less steady and powerful when cyclones are numerous than when they are few. We may, therefore, with some show of reason, conclude that the great convection currents of the atmosphere increase and diminish in steadiness and velocity in the way here indicated, and if they do, the variation of the winter rainfall of India can be satisfactorily accounted for. That the winter rainfall of temperate regions is subject to a fluctuation similar to that of Northern India, is rendered highly probable by the circumstance, that at nearly all the stations in North Africa, Western Asia, and Southern Europe, where the chief rainy season is *in winter*, the total fall of the year is below the mean at times when the sunspots are numerous—that is, when the temperature of the tropics is below the mean, and

[1] The dates given in brackets are only estimates founded on the apparent average interval from maximum to maximum.
[2] *Nature*, Vol XVI, page 506.
[3] *See* Mr. J. Eliot's Report on the Vizagapatam and Backergunge Cyclones of October 1876.

above the average when the sun is free from spots—that is, when tropical regions are hotter than usual. This result has been arrived at by the late Professor Jelinek, and is given in his article in the *Journal of the Austrian Meteorological Society*, Vol. VIII, No. 6. The winter rainfall of London is subject to a variation similar to that of Northern India, as shown by the following table, which represents the mean rainfall of the months of January, February, March, October, November and December, for each year of the eleven-year cycle, commencing with 1860, &c.

TABLE VII.

Years of the cycle	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	
Observed	11·47,	12·44,	10·38,	12·89,	10·19,	12·59,	15·80,	10·20,	12·71,	11·98,	11·63.	inches.
Corrected	11·75,	11·68,	11·52,	11·59,	11·47,	12·79,	13·60,	12·23,	11·90,	12·07,	11·68.	„

The figures are taken from a table by Mr. G. Dines, published as a supplement to the third part of the *Quarterly Weather Report* for 1873. They extend over the sixty years 1813—1872. The second line gives the triennial means when the middle year is allowed double weight. Dr. Draper, in his report on the Meteorology of New York for the year 1876, has shown that the winter rainfall of that station is also subject to a similar variation.

For some reason, however, which is by no means obvious, the summer rainfall of London and other stations in Western Europe resembles that of the countries bordering on the Indian Ocean in being heaviest at times of maximum sunspots, but it is probable that in the interior of continents this also is greatest at the period of highest tropical temperature. A reference to Table I, given above, will show that at eight stations on the borders of the monsoon region, the summer rainfall of the 4th, 5th, and 6th years of the cycle is greater than that of the 11th, 1st, and 2nd years. The triennial means for these two periods are given in the following Table:—

TABLE VIII.

Mean Summer rainfall of Stations on the borders of the Monsoon Region.

Stations.	Bannu.	Peshawar.	Ambala.	Simla.	Rawal Pindi.	Lahore.	Gujranwala.	Sibsagar.
Mean of 11th, 1st and 2nd years ...	5·50″	6·00″	32·07″	59·17″	22·80″	9·50″	16·80″	77·40″
Mean of 4th, 5th and 6th years ...	10·93″	6·50″	34·56″	62 73″	27·55″	18·53″	23·61″	78·15″

The first three years represent approximately the coolest part of the cycle, and the other three the hottest. Only two of the stations of the North-West Panjab, included in Table I, exhibit an opposite relation between the summer rainfalls of the two epochs. These are Abbottabad and Shahpur, and the excess of rainfall in the cool period is inconsiderable in both cases.

The depth of water in the rivers of Northern Europe is said to vary slightly with the sunspot area, but whether this variation is more nearly direct or inverse I do not know. In America, the great lakes fluctuate in level according to the same cycle, and from a

diagram of the relative heights of the water-level of these lakes at different periods, given in a paper by Mr. G. M. Dawson, in *Nature*, Vol. 9, page 506, it would seem that high-water generally precedes the sunspot maximum, by two or three years, being thus apparently an effect of the high temperature and heavy winter rain of the years about the previous sunspot minimum.

Another important meteorological element, the absolute humidity of air, seems to vary in the same way in the interior of continents. Mr. H. F. Blanford, in the *Indian Meteorologist's Vade Mecum*, page 225, gives a table showing that there was a regular decrease in the tension of vapour in the atmosphere at Colombo from the year 1871 to 1876. This may, perhaps, be fairly assumed to represent the variation of the absolute humidity of the air over the northern part of the Indian Ocean; and, as far north as the Himalaya, the vapour tension appears to vary in the same general way, though by no means so regularly. Thus, from the next table, which represents the mean vapour tension at Roorkee at 10 A.M., and 4 P.M., we see that the highest numbers for the whole, year correspond to 1871 and 1875, and the lowest to 1876 and 1877 :—

TABLE IX.

Mean Vapour Tension at Roorkee.

	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Year	·534″	·550″	·545″	·568″	·560″	·518″	·536″	·568″	·509″	·493″
March	·372	·440	·395	·303	·371	·327	·368	·387	·354	·393
July	·854	·901	·950	·926	·925	·909	·936	·923	·860	·776

The tensions in July vary more regularly, reaching the maximum in 1870, and the minimum in 1877, with a secondary minimum in 1873. On the other hand, the vapour tension during March, which is the cold-weather month of greatest precipitation at the North-Western stations, reached its minima in 1871 and 1873, and its maxima in 1869 and 1877, the numbers following closely the variations of tropical temperature as shown by the curve, figure 3. At Bombay, to the south of the region of the winter rains however, this variation of the vapour pressure can hardly be traced. I am indebted to Mr. C. Chambers, F.R.S., for a table of the mean vapour tensions recorded at the Colaba Observatory from 1871 to 1877, which, added to the results published in the Observatory Report for 1865-70, gives a table covering thirteen years. The mean for 1877 is the highest in the series for the whole year, and that for 1872 the lowest. For the winter months, October, November, December, January, February and March, the highest mean vapour tensions are those of 1868, 1871 and 1877, and the lowest those of 1866, 1872, and 1874.

When we cross the Himalaya and come to the stations of the Russian Empire, we find that the mean annual vapour tension fluctuates periodically in the same way as the winter rainfall of Northern India; and that some even of the minor fluctuations of the two phenomena coincide; showing that they are probably concurrent effects of the same cause. Out of the immense quantity of data given in Dr. H. Wild's elaborate

paper on the diurnal and annual march of humidity in Russia,[1] I have chosen the annual registers of seven stations as widely distributed as is consistent with the condition that each register must be at least twenty years long. These are St. Petersburg, Catherinenburg, Slatoust, Barnaul, Nertschinsk, Lugan, and Tiflis. The annual mean vapour tensions of these stations, when arranged in eleven-year series, give the following percentage deviations from the mean for each year of the cycle commencing with 1860, &c.:—

TABLE X.

Years of the cycle	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th.
Variation ...	− 1·2	− 1·2	− 1·4	+ 1·3	+ 0·6	+ 2·2	+ 0·2	− 0·3	+ 0·2	+ 1·6	− 1·1

The lowest degree of absolute humidity at inland stations thus appears to occur in the 11th, 1st, 2nd, and 3rd years of the cycle, and the highest in the 4th, 5th, and 6th, and there is a secondary minimum in the 8th year; in most of which points this agrees with the winter rainfall of Northern India and the summer fall of the eight stations on the borders of the monsoon region given in Table VIII. The lowest curve, *fig.* 4, *in* the plate at the end of the paper, represents the variation of this element from year to year, when the variation of each single year is modified by adding to it half the sum of those for the preceding and succeeding years, and dividing by two. Here also the evidence of a periodic repetition of the phenomenon is very strong, and the form of the curve is very like that of the temperature curve in every part except about the secondary minimum in 1845.[2] It may therefore be fairly concluded, that winter rains in Northern India occur simultaneously with an increase in the quantity of aqueous vapour in the atmosphere over Eastern Europe and Western Asia, and that the cause of both may possibly be found in an unusually high temperature in the tropics, whereby the evaporation of the waters of the ocean is accelerated, and the upper current of moist air, known as the antitrade, has its velocity increased.

Former Droughts and Scarcities.

The records of former droughts and scarcities do not throw any very clear light on the question of the variation of the winter rains. From Mr. Girdlestone's *Past Famines in the North-Western Provinces* we learn that, since the country came under British rule, famines or scarcities due to the failure of the summer rains have occurred in the years 1783-84, 1803-4, 1813-14, 1825-26, 1833-34, 1837-38, and 1860-61. To these we may add the more recent famine of 1866, in Orissa, and of 1868-69 in Rajputana, as well as those of 1873-74 and 1877-78 with which every one is familiar. The first and greatest of these famines corresponded to a sunspot minimum, and we read that the distress abated at the end of February, owing, doubtless, to the fall of good winter rains. The second occurred at a sunspot maximum, and the succeeding winter rains failed, thus aggravating the distress which was at first slight. The third occupied an intermediate portion of the solar cycle, and the winter crop that succeeded it was a good one. The drought of 1825 occurred nearly midway between minimum and maximum, and there was a general failure of the succeeding winter rains; that of 1833

[1] *Repertorium fur Meteorologie*, Vol. IV., No. 7.
[2] This was an unusually cold year at all the Russian Stations.

coincided with the sunspot minimum; but we have no information regarding the winter rains of 1834, excepting that at Calcutta, as shown by the table in the Appendix, they were somewhat below the average.

The great famine of 1837-38, and that of 1860-61, both occurred at times of maximum sunspots. There was, in both cases, a partial failure of the summer rains, followed by an almost complete absence of the usual winter fall; and in 1860 the rains, which even in the driest years generally came down about the end of September, or the beginning of October, preparing the ground for the winter crops, failed entirely. The drought of 1868, on the other hand, like those of 1876 and 1877, ended with a good downpour of rain at the end of the season, and was followed by fairly abundant winter rains.

The summer rains of the North-Western Provinces and Rajputana have, therefore, failed quite as often when sunspots were numerous as when they were few; but whereas, in the former case, a comparatively slight scarcity has generally been developed into a severe famine through the failure of the winter rains, this has seldom happened in the latter case, the distress at such times being alleviated by the ingathering of the *rabi* harvest, rendered more abundant than usual by a copious winter fall. The facts here pointed out, together with the circumstance that the sunspot period itself varies greatly in duration, render it obviously impossible to predict the occurrence of droughts and famine years before they actually happen. The utmost they can do is to afford a rather strong presumption, that when the summer rains fail, as they did in 1877, at a time when the sun is free from spots, the succeeding winter rains will be up to or over the average, and that when a dry summer occurs, as in 1860, at a time of maximum sunspot, there is a certain probability that the winter rains will fail also.

Attempted Explanation.

The observed variations of temperature, humidity, and rainfall, detailed above, when studied in connection with the laws of the monsoons, will probably serve to explain this impartial distribution of drought and famine between the two epochs of the sunspot cycle in North-Western India, and at the same time may show why Southern India resembles most tropical countries in having least rain about sunspot minima; while the seasons of Burma, in the same latitude, appear to vary in the inverse direction.

Taking for granted that there is an eleven-year cycle of temperature, we may fairly assume that the range of the oscillation will resemble that of the daily and yearly variation in being much greater on land than at sea, and in being greatest of all in dry and desert tracts such as Sindh and Rajputana. Countries like the greater part of the Madras Presidency, the North-Western Provinces, and the Punjab, that are nearly devoid of timber, will show a much greater amplitude of temperature variation than others, such as Burma and Lower Bengal, which are well clothed with forest or other vegetation. The great half-yearly reversal of the winds over the Indian continent, commonly known as the change of the monsoons, being primarily caused by the greater range of temperature in the interior and north-western part of the continent of

India than over the ocean to the south, it is probable that the indraught of moist air, which constitutes the summer monsoon, will be more powerful at a period of high terrestrial temperature than when the general temperature of the earth's surface is below the mean. On this theory, the summer rains of Rajputana and the adjacent parts of the North-Western Provinces and the Panjab should be defective at times when the general temperature of the tropics is defective, owing to the monsoon current being then unusually feeble. A notable instance of this occurred in 1837, and minor instances occurred in 1864 and 1873. On the other hand, in years like 1833, 1866, 1868, and 1877, when the tropical temperature is high, the monsoon current should set in with unusual strength; but if the temperature of the land be very much higher than that of the sea, as it undoubtedly is in such years, a current of air, which is saturated, or nearly saturated, with vapour as it leaves the sea, will, without any precipitation of moisture, become drier and drier as it passes inland, unless it meets with some obstacle, such as a mountain range, or is forced in some other way to rise upwards and lose heat by expansion. We might therefore expect that in Northern India such a current would only begin to precipitate its vapour when it reached the Himalaya, or the extreme north-west of the Panjab. This has been well illustrated during the present rainy season (1878). The temperature of the North-Western Provinces in June and July was unusually high, and the indraught from the Bay of Bengal was very powerful; yet the rainfall of the central and eastern parts of these provinces was far below the average in July and August, and also in September—the unusually high temperature continuing to the end of the season; and there was a corresponding excess of precipitation in the Panjab and the north-western part of these provinces.

It has been pointed out by Mr. Blanford that in India the variations in the direction of the wind, by which the distribution of the rainfall is controlled, are apparently the effect, not so much of the absolute distribution of atmospheric pressure at any time, as of the relative excess or defect of the actual pressure at each place when compared with the average for many years, and of the relative distribution of these pressure anomalies. It appears that in hot years, such as we have been considering, there is always, for some reason not fully understood, a relative excess of pressure towards the north-west of India, which has the effect of deflecting the current which generally sets in towards Rajputana from the Arabian Sea in a southerly direction, thus sending its moisture to be precipitated on the hills of Central India instead of on Rajputana and Bundelkhand. Another effect of this high pressure towards the west is the production or continuation of a strong, dry, westerly current down the Gangetic Valley, which effectually bars the way of the south-easterly current from the Bay of Bengal, compelling it to pour out its moisture over the lower provinces. This condition was maintained all through the monsoon months of 1877, as well as in the earlier part of 1876, and there is some evidence that similar conditions prevailed in 1868 and the beginning of 1869,[1] and perhaps, also, in 1833, and previous famine years. In illustration of this point, I have drawn up the following tables which represent the pressure anomalies of four stations in the North-Western Provinces for different years. The pressures from which the

[1] See Mr. H. F. Blanford's papers in the *Journal of the Asiatic Society of Bengal*, Part II, Vol. XIV, page 27, and Vol. XXXIX, page 123. See also the *Indian Meteorologist's Vade Mecum*, page 97.

tables are calculated are the means of the 10 A.M. and 4 P.M. observations, and the standard of comparison adopted for each station is the average monthly pressure for the ten years, 1868—77.

TABLE XI.

Total Barometric Anomalies, 1865.

	January.	February	March.	April.	May.	June.	July.	August	September.	October.	November.	December.
Roorkee ...	+·182	+·046	+·091	+·004	—·011	+·007	—·017	+·017	—·012	—·016	—·020	—·009

The year 1865 was characterised by excessively heavy snow and rainfall on the Himalaya in January, February, and March, amounting at Naini Tal to 39·66 inches for the three months, according to the published reports (though these seem rather doubtful), the average being only 8 inches. In January alone over 16 inches fell, chiefly in the form of snow. The chilling effect of this widely extended snowfall is seen in the excessively high pressure of the first three months of the year at Roorkee. In May the pressure fell considerably below the mean at Roorkee, and the rainfall of the month was in excess. In June the pressure was a little above the average, but in July it again fell below it, and the summer rains then set in in full force. The fall was up to the average everywhere, and in the Himalayan stations was very excessive in August and September. The year was thus one with copious winter rains and snows, followed by abundant summer rains, which set in a nearly month later than usual.

TABLE XII—A.

Total Barometric Anomalies, 1867.

	January.	February	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee	+·010	0	+·031	+·036	−·013	+·037	+·010	−·001	−·041	+·021	+·053	+·052
Agra	+·047	+·028	+·056	+·052	+·026	+·042	+·037	−·006	−·034	−·019	+·046	+·040
Ajmere	+·030	+·006	+·022	+·009	−·024	−·015	−·005	−·076	−·018	+·024	+·045	+·032

TABLE XII—B.

Relative Barometric Anomalies, 1867.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee to Agra ...	−·037	−·028	−·025	−·016	−·039	−·005	−·027	−·005	−·007	+·040	+·007	+·012
Ajmere to Agra ...	−·017	−·022	−·034	−·043	−·050	−·057	−·042	−·070	+·016	+·043	−·001	−·003

The winter rains of 1867 were far below the average in amount, and the months of March, April, and May were nearly rainless. The pressure at the three stations in Table XII was generally over the average up to the end of April, but was relatively least at the northern and western stations. The pressure was in defect at Roorkee in

May, and the relative difference between Roorkee and Agra amounted to nearly ·01". The summer monsoon set in early and brought good rain in June; and on the total of the summer months the rainfall was generally above the average. The easterly current which brought in the rain appears to have been strengthened by the relative defect of pressure in Rajputana towards which it blew. The pressure, both of the early months and of the rainy season, was thus defective towards the north and west, the relative *defect at the northern station being greatest in May, and the apparent consequences were* a comparatively dry winter and hot weather, and early and abundant summer rains. The meteorological features of the following year were just the opposite in both these respects.

TABLE XIII—A.

Total Barometric Anomalies, 1868.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee	+·020	0	+·013	+·018	+0·83	+·010	+·022	−·035	−·015	+·008	−·012	+·015
Agra	+·019	−·003	+·027	+·023	+·059	+·005	+·013	−·027	−·010	+·002	−·025	−·002
Benares	+·076	+·012	+·034	+·014	+·086	+·022	+·030	+·004	−·003	+·014	+·004	+·030

TABLE XIII—B.

Relative Barometric Anomalies, 1868.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee to Agra ...	+·001	+·003	+·016	−·005	+·024	+·005	+·009	−·008	−·005	+·006	+·013	+·017
Roorkee to Benares ...	−·056	−·012	+·009	+·004	−·003	−·012	−·008	−·039	−·012	−·006	−·016	−·015
Agra to Benares ...	−·057	−·015	−·007	+·009	−·027	−·017	−·017	−·031	−·007	−·012	−·029	−·032

In 1868 the pressure over Northern and Western India was generally above the average up to the end of July, the excess amounting to nearly a tenth of an inch in May. The winter rains were much more copious than they usually are, and there was a general failure of the summer rains; but in the middle of September a storm swept up from the head of the Bay which afforded sufficient rain to prepare the ground for the succeeding winter crop. The differences of the pressure anomalies over the North-Western Provinces were small throughout the greater part of the year, and the persistency of the westerly winds of that year appears to have been due to the formation of a centre of relatively low pressure at the north-west angle of the Bay of Bengal. Thus the relative monthly anomalies of Benares compared to Saugor Island were—

January.	February.	March.	April.	May.	June.
+·060"	+·051"	+·044"	+·046"	+·032"	+·065"
July.	**August.**	**September.**	**October.**	**November.**	**December.**
+·050"	+·132"	+·069"	+·035"	+·053"	+·018"

In August, the month when this barometric minimum at the head of the Bay became most distinct, the rainfall in Lower Bengal was almost unprecedentedly heavy, whilst in Upper India hardly any rain fell.

The next table gives the barometric variations for a year, which in the distribution of its rainfall features closely resembled 1867, the winter rains being defective and those of the summer monsoon unusually heavy.

TABLE XIV—A.

Total Barometric Anomalies, 1870.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December
Roorkee ...	−·065	−·036	−·013	+·013	−·071	+·029	−·034	−·020	+·005	−·035	−·028	−·016
Agra ...	−·057	−·058	−·030	−·014	−·070	+·007	−·055	−·032	−·004	−·049	−·038	−·019
Ajmere ...	−·037	−·042	−·031	−·015	−·032	+·017	−·035	−·019	+·003	−·034	−·044	−·036
Benares ...	−·044	−·027	−·007	+·013	−·058	+·027	−·025	−·009	+·005	−·037	−·010	+·001

TABLE XIV—B.

Relative Barometric Anomalies, 1870.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee to Agra ...	−·012	+·022	+·017	+·027	−·001	+·022	+·021	+·012	+·009	+·014	+·010	+·003
Roorkee to Benares	−·021	−·009	−·006	0	−·013	+·002	−·009	−·011	0	+·002	−·018	−·017
Ajmere to Agra ...	+·020	+·016	−·001	−·001	+·038	+·010	+·020	+·013	+·007	+·015	−·006	−·017
Ajmere to Benares	+·007	−·015	−·024	−·028	+·026	−·010	−·010	−·010	−·002	+·003	−·034	−037

The pressure of the atmosphere in Northern India in 1870 was below the mean, excepting in June, not above it, as in the early months of 1867; but, as in 1867, there was a marked local depression at Roorkee in May, preceding the setting in of the rains. The defective snowfall was perhaps connected with the depression of the barometer at the northern station in January, but during the greater part of the rainy season the relative defect was greatest at Agra and Ajmere.

TABLE XV—A.

Total Barometric Anomalies, 1873.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee ...	−·032	−·024	−·029	−·064	+·035	−·090	−·054	+·019	−·018	+·010	+·046	+·003
Agra	−·019	+·007	+·006	−·022	+·070	−·036	−·017	+·037	−·002	+·027	+·059	+·017
Ajmere ...	−·016	+·012	+·006	−·010	+·038	−·012	−·021	+·036	+·005	+·006	+·031	+·012
Benares ...	−·073	−·025	−·029	−·049	+·018	−·060	−·041	?	?	?	?	?

TABLE XV—B.

Relative Barometric Anomalies, 1873.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee to Agra ...	−·013	−·031	−·035	−·012	−·035	−·051	−·037	−·018	−·016	−·017	−·013	−·014
Roorkee to Benares	+·011	+·001	0	−·025	+·017	−·030	−·013	?	?	?	?	?
Ajmere to Agra ...	+·003	+·005	0	+·012	−·032	+·024	−·005	−·001	+·007	−·021	−·028	−·005
Agra to Benares ...	+·054	+·032	+·035	+·027	+·052	+·021	+·024	?	?	?	?	?

The pressure of the first four months of 1873 was generally below the average in Northern India, that of May was excessive, and that of June and July greatly in defect at each of the four stations in the table. The table of relative anomalies shows that the pressure throughout the year was relatively defective at Roorkee, and also at Benares, at least up to the end of July, the depression at the eastern station being the greater. This was apparently connected with the prevalence of westerly and south-westerly winds over the greater part of the North-Western Provinces and Behar during the summer months, when the rainfall of these districts was greatly in defect.

TABLE XVI—A.

Total Barometric Anomalies, 1874.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee ...	+·016	−·002	−·035	+·007	−·081	+·010	+·012	−·007	−·017	−·040	+·012	+·007
Agra	+·044	+·016	−·007	+·026	−·033	+·028	+·041	−·005	−·008	−·032	+·023	+·027
Ajmere ...	+·028	+·010	−·022	+·026	−·021	+·002	+·021	−·007	+·005	−·039	+·012	+·020
Benares ...	+·028	+·011	−·002	+·024	−·057	+·062	+·061	−·009	+·004	−·037	+·027	+·023

TABLE XVI—B.

Relative Barometric Anomalies, 1874.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Roorkee to Agra ...	−·028	−·014	−·028	−·019	−·048	+·012	+·001	+·002	−·009	−·008	−·011	−·020
Roorkee to Benares	−·012	−·013	−·033	−·017	−·024	−·022	−·019	−·002	−·021	−·003	−·015	−·016
Ajmere to Agra ...	−·016	−·006	−·015	0	+·011	−·026	−·020	−·002	+·013	−·007	−·011	−·007
Ajmere to Benares...	0	−·001	−·020	−·002	+·036	−·060	−·040	−·002	+·001	−·002	−·015	−·003

The winter rains of 1874 were fairly abundant, though not up to the average, and the summer rains were greatly in excess. The barometer was abnormally low at Roorkee during the first five months, as compared with the other stations, notably so in

May, but throughout the rainy season the relative anomaly at Roorkee was very small. In June and July, however, a relative depression appeared at Ajmere, which seems to have had the effect of intensifying the easterly wind from the Bay of Bengal, and consequently rendering the rainfall excessive.

The year 1877 was strongly contrasted with 1874 in both respects, the winter rains being unprecedentedly heavy and the summer rain almost entirely wanting. The atmospheric pressure all over Northern India was above the average for the greater part of the year, and the excess at the western stations was very marked and persistent, and attained its maximum in what should have been the middle of the rainy season.

TABLE XVII—A.

Total Barometric Anomalies, 1877.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November	December
Roorkee ...	+·067	+·067	+·043	+·088	+·050	+·057	+·001	−·015	+·013	+·052	−·009	− 013
Agra	+·083	+·070	+·031	+·067	+·068	+·055	+·035	−·010	+·032	+·056	+·002	0
Ajmere ...	+·078	+·055	+·034	+·057	+·056	+·059	+·065	+·052	+·053	+·048	+·013	−·005
Benares ...	+·054	+·073	+·024	+·050	+·023	+·009	+·007	−·050	−·005	+·019	−·037	− 030

TABLE XVII—B.

Relative Barometric Anomalies, 1877.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December
Roorkee to Agra ...	−·016	−·003	+·012	+·021	−·018	+·002	−·034	−·005	−·019	−·004	−·011	−·013
Roorkee to Benares	+·013	−·006	+·019	+·038	+·029	+·048	−·006	+·035	+·018	+·033	+·028	+·017
Ajmere to Agra ...	−·005	−·015	+·003	−·010	−·012	+·004	+·030	+·062	+·021	−·008	+·011	−·005
Ajmere to Benares ..	+·024	−·018	+·010	+·007	+·033	+·050	+·058	+·102	+·058	+·029	+·050	+·025

From these examples, and from those given by Mr. Blanford in the papers above referred to, it is abundantly evident that there is a connection, probably casual, between the distribution of the pressure anomalies before and during the rainy season and that of the rainfall. It will be seen that a heavy winter rainfall generally coincides with a high barometric pressure over Northern India, the excess of which is most distinct at the most northern stations; and that in years when the pressure at the northern and especially at the north-western stations is relatively higher than elsewhere during April and May, the summer rains are generally late, scanty, and irregularly distributed.

Mr. Blanford, in his report on the Meteorology of India for 1876, adduces the unusually abundant snowfall on the north-western Himalaya in the beginning of the year as the probable cause of the abnormally high pressure of the Panjab that year; but he admits that this cause probably is not the only one, since the high pressure was equally

well marked at Bombay and in the lower Indus Valley. This latter, it should be remarked, and not the high pressure of the Panjab, would seem to have been the proximate cause of the failure of the rains which produced the great famine in Southern India.

It is, no doubt, true that a heavy snowfall on the Himalaya may be a cause of high atmospheric pressure all over the north of India in the spring months, but it is difficult to see why the high pressure due to this cause should continue up to the end of September, as it did in 1877; and in the present state of meteorological science, it would, I think, be impossible to show how a somewhat greater area of snow than usual on the Himalaya, in winter, should produce an abnormally high atmospheric pressure over the Bombay coast and the ocean to the west in the summer months. The Himalayan snowfall of 1876 does not seem to have been very much in excess of the average, though perhaps its lateness may have rendered it more effective as a cooling agent, and the winter precipitation for that year at the stations given in the appendix, was 40 per cent. below the mean. Yet the pressure towards the north-west of India was so high during the summer as to give an undue westerly direction to the winds, and cause the rainfall to be defective almost everywhere in India except in Lower Bengal. It should also be noted that the winter rain of the present year (1878), and probably also the Himalayan snowfall, was very much heavier than in 1876, and yet the pressure over the Bombay coast and in Sindh was this year somewhat below the average, and the easterly summer winds of Northern India have blown with nearly their usual force.

We must therefore look to some more general cause; and it is to be regretted that at present our knowledge of the atmosphere and its laws is not sufficiently complete to suggest the cause required. The only explanation I can venture to put forward is a purely speculative one, though it is just possible that facts may yet be discovered which will lend some support to it. It is this. During the summer months there is a general tendency to a cyclonic movement of the atmosphere round the Asiatic continent, as well as a smaller cyclonic circulation round Upper and Central India; and it is possible that in years of high terrestrial temperature the general movement may be so intensified as partially to obliterate the minor cyclonic indraught towards Central India and Rajputana which brings the monsoon rains to the Gangetic Valley. It is worthy of note that Mr. J. A. Broun, F.R.S., in a discussion of the atmospheric pressure of the British Isles, totally unconnected with this subject, has discovered a similar excess of pressure to the west in warm, as compared with cool years, or, as he puts it, in years of minimum as compared with years of maximum sun-spots,[1] indicating that the prevalent westerly winds of Europe then blow more steadily than usual. This explanation requires that the velocity of the wind should be greater in hot than in cool years,—a point regarding which there is at present very little direct evidence forthcoming, though, as I have already shown, the prevalence of cyclones in cool years, and their comparative absence in hot years, lends some support to the theory. The anemometer records of many Indian stations at first sight appear to support this view, but unfortunately the exposure of the instruments at most of the stations has not always been the same, so that the velocities from year to year are not comparable *inter se*. In that part of the country

[1] Proc. R. S., vol. xxv, p. 519.

over which the prevalent summer winds are easterly and westerly in wet and dry years respectively, there are, however, two stations at which the velocity of the wind has been measured for eight or nine years, and at which the figures for one year are comparable with those for another, owing to the anemometers having a good exposure, and to their positions never having been changed. These stations are Agra and Bareilly. In the following table is given the mean recorded velocity of the wind in miles per diem at each of these stations, and the figures show clearly that the mean velocity was least at one of the minima of summer rainfall, 1873, and increased again up to the other year of minimum rainfall, 1877.

TABLE XVIII.

Mean daily velocity of the Wind.

	1869.	1870.	1871.	1872.	1873.	1874.	1875	1876	1877.
Agra	121	180	100	94	86	97	102	103	111[1]
Bareilly	124	114	89	64	67	72	75	...	101[2]

The wind velocity at these stations obviously varies in the same sense as the temperature and the winter rainfall for the few years given in the table. No general conclusion can safely be drawn from such a short series of observations, although, as explained above, there is a certain probability that the wind will vary in this way, at least in that part of the country subject to either easterly or westerly winds according as the year is wet or dry. Should further observations confirm this conclusion, and also prove that when the winter and spring rainfall has been above the average there is always a relative excess of barometric pressure towards the west, it will be easy to explain why the summer rain of Lower Bengal should reach a maximum every fifth or sixth year. In years like 1834, 1844, 1855, 1868, and 1876 or 1877, the summer rainfall would be excessive because the moist current from the Bay would be prevented from passing up the Gangetic Valley by high pressure to the west; and in years like 1839, 1849, 1861, and 1871, it would be greater than usual on account of the monsoon current being comparatively feeble and having little tendency to pass far inland; and because of the circumstance that the difference of temperature between the plains of Bengal and the sea being then less than the average, the air would have but little tendency to grow drier as it passed inland, except by precipitating its moisture. That this is so, rendered probable by the circumstance pointed out by Mr. Broun in *Nature,* vol. XVI, page 334, that in Southern India there is a well-marked five-yearly periodicity in the rainfall, which has its minima at the maxima and minima of sun-spots, and is therefore exactly opposite to that of the rainfall of Bengal. Years of maximum sun-spots are there most probably years of weak monsoons, and years of minimum spots are doubtless hotter than usual, and are probably characterised by the prevalence of northerly elements in the winds.

[1] Seven months only.

[2] Ten months only.

The excess of pressure towards the west would also explain why, in years when the south-west monsoon passes over the arid tracts of the Madras Presidency without precipitating a drop of rain, the wooded flats of Burmah and the hills of the Arakan coast are suffering from a superabundance of moisture.

This explanation is too speculative, however, to be of much value, and the general conclusion to be drawn from the foregoing discussion will, therefore, be that we are yet very far from having discovered the laws of the variations of the rainfall brought by the summer monsoon; but that it is highly probable that the winter rains of Northern India are subject to a periodical increase and diminution coinciding with, and possibly caused by, a similar variation in the temperature of the tropics. Whether this be directly or indirectly due to periodical changes in the intensity of solar radiation is a question worth investigating, but one into which it is not necessary at present to enter.

POSTSCRIPT.

Since the preceding paper was written, I have discovered in the Office of the Board of Revenue at Allahabad complete records of the rainfall of each sudder station in the N.-W. Provinces from May 1844 to October 1855. Records also exist for each year, from June 1860 to the present time. The gap between 1855 and 1860 has been bridged over by means of registers kept in the Himalayan province of Kumaon, to which the civil disturbances following the mutiny of 1857 did not extend. From these the average winter and summer rainfalls of the province for each year have been calculated, the Kumaon returns from 1856-60 being supplemented by those of Jabalpur, Ambala, Shahpur, and Gujranwala. The rainfall of each season has been calculated in percentages of the average for many years, in the following way. If the rainfalls of a number of stations 1, 2, 3, ... n for any given year be $r_1, r_2, r_3, \ldots\ldots r_n$, respectively, and the averages for the same places during many years $R_1, R_2, R_3, \ldots\ldots R_n$, the proportionate number for the year is given by the formula—

$$\text{Percentage} = 100 \times \frac{r_1 + r_2 + \ldots\ldots r_n}{R_1 + R_2 + \ldots\ldots R_n}$$

The percentages representing the summer and winter rainfall of each year and the number of stations on which the figures for each year are founded are given in the following table:—

Table showing the mean rainfall of the North-Western Provinces for each year from 1844 to 1878, in percentages of the average for many years.

Years.	Winter rain.		Summer rain.		Years.	Winter rain.		Summer rain.	
	No. of Stations.	Per cent.	No. of Stations.	Per cent.		No. of Stations.	Per cent.	No. of Stations.	Per cent.
1844	...	...	28	87	1848	29	72	30	73
1845	29	143	29	91	1849	30	92	31	90
1846	29	66	29	106	1850	31	160	38	87
1847	28	76	29	105	1851	38	183	38	82

Table showing the mean rainfall of the North-Western Provinces for each year from 1844 to 1878, in percentages of the average for many years—concluded.

Years.	Winter rain.		Summer rain.		Years.	Winter rain.		Summer rain.	
	No. of Stations.	Per cent.	No. of Stations.	Per cent.		No of Stations.	Per cent.	No of Stations.	Per cent
1852	38	109	38	94	1866	41	103	41	92
1853	38	117	38	91	1867	42	91	42	135
1854	38	61	35	123	1868	42	146	42	66
1855	34	172	35	101	1869	42	109	43	97
1856	7	49	11	129	1870	43	103	43	121
1857	10	86	10	97	1871	43	61	44	131
1858	9	63	9	101	1872	44	152	44	111
1859	9	160	9	89	1873	44	46	44	101
1860	9	76	30	54	1874	44	71	44	131
1861	32	23	26	128	1875	44	70	44	114
1862	27	65	32	123	1876	43	46	44	93
1863	40	54	39	115	1877	39	174	39	45
1864	40	71	40	69	1878	39	217	39	90
1865	40	147	41	95					

The figures for the winter rain agree fairly with those of Table V in the preceding paper, except in the years from 1849 to 1854. The differences in these years are partly due to the slightly different way in which the winter rainfall of each year has been calculated. In the text the winter fall of each year consists of two portions, one, January to April, at the beginning, and the other, November and December, at the end. In drawing up the table here given, however, it was thought better to include the November and December of the preceding year with the January, February, March and April of each year in the table, to avoid breaking up the winter season; and in years when there is any rain in November and December, this affects the totals considerably.

The mean amplitude of the variation at these North-Western Provinces stations alone appears to be somewhat less than when the wider area, with a larger proportion of Himalayan stations, is included in the calculation. The corrected mean variations for each year of the supposed 11-year cycle, as given in the text and as deduced from these figures, are here compared—

Years.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.
Text ...	−17·1	−13·6	−18·8	−20·4	− 7·8	+23·1	+35·6	+15·7	+10·2	+ 4·9	−14·9
North-Western Provinces Stations ...	− 6·8	− 0·6	− 3·6	−15·5	−17·3	+ 0·8	+27·3	+24·7	+ 2·1	− 5·6	− 5·4

The differences may be partly real and partly due to the circumstance that in striking these averages (as will be seen from the above formula) every station has been

given a weight proportional to its actual rainfall, whereas in the text all the stations have been assigned equal weights.

These results strongly support my original conclusion that the winter rains are heaviest when the summer rains are defective, and *vice versa*. They also support the idea put forward by Mr. Blanford in his report for 1876, that an unusual amount of precipitation over Northern India and the Himalaya in winter and spring may, by modifying the normal distribution of pressure, cause the rainfall of the succeeding summer to be defective in the Gangetic valley; though of course, they throw no light on the question of the influence of the Himalayan snowfall on the meteorology of the Bombay Presidency.

Thus the following twelve years had the winter rainfall excessive and that of the summer defective, *viz.*, 1845, 1850, 1851, 1852, 1853, 1859, 1865, 1866, 1868, 1869, 1877 and 1878, and the thirteen years, 1846, 1847, 1854, 1856, 1858, 1861, 1862, 1863, 1867, 1871, 1873, 1874 and 1875 had dry winters followed by wet summers. Against these twenty-five instances in favour of the rule, we have only three years, 1855, 1870, and 1872, with the rainfall excessivé in both seasons, and six years, 1848, 1849, 1857, 1860, 1864 and 1876, with a deficiency both in summer and in winter. If ten or eleven per cent. be allowed as the probable error of the figures for each year, owing to the short periods on which some of the averages are founded, and to the inaccuracies of many of the earlier observations, the exceptions to the rule are reduced to two, 1848 and 1860, bo theyars of maximum sunspot.

APPENDIX.

Rainfall Tables.

1. CALCUTTA.

Years.	Winter.	Summer.	Total.	Years.	Winter.	Summer.	Total.
	In.	In.	In.		In.	In.	In.
1829	1·90	58·04	59·94	1854	10·44	56·03	66·47
1830	7·26	56·02	63·28	1855	5·53	64·83	70·36
1831	7·48	49·42	56·90	1856	3·91	60·32	64·23
1832	8·57	42·15	50·72	1857	2·76	66·21	68·97
1833	7·12	53·44	60·56	1858	2·88	56·88	59·76
1834	4·35	64·38	68·73	1859	6·18	62·48	68·66
1835	6·64	78·86	85·50	1860	2·56	50·05	52·61
1836[1]	2·57	43·09	45·66	1861	6·40	82·79	89·19
1837	2·26	41·35	43·61	1862	5·45	68·03	73·48
1838	1·91	51·08	52·99	1863	4·89	56·26	61·15
1839	4·25	60·72	64·97	1864	6·31	77·91	84·22
1840	1·24	58·17	59·41	1865	8·58	53·00	61·58
1841	5·11	55·14	60·25	1866	7·46	58·28	65·74
1842	8·44	67·68	76·12	1867	8·06	64·67	72·73
1843	6·79	57·55	64·34	1868	5·86	85·63	91·49
1844	3·65	70·21	73·86	1869	8·41	53·59	62·00
1845	10·02	50·90	60·92	1870	6·49	53·77	60·26
1846	7·75	68·69	76·44	1871	11·88	81·43	93·31
1847	7·97	64·39	72·36	1872	5·19	45·86	51·05
1848	2·08	56·61	58·69	1873	3·98	41·29	45·27
1849	7·58	62·93	70·51	1874	7·97	53·51	61·48
1850	6·57	69·71	76·28	1875	5·45	54·44	59·89
1851	7·28	56·88	64·16	1876	7·68	72·55	80·23
1852	10·00	71·41	81·41	1877	8·82	52·24	61·06
1853	1·10	50·98	52·08				

[1] April wanting.

Rainfall Tables—continued.

Years.	2. Monghyr. Winter.	2. Monghyr. Summer.	2. Monghyr. Total.	3. Benares. Winter.	3. Benares. Summer.	3. Benares. Total.	4. Allahabad. Winter.	4. Allahabad. Summer.	4. Allahabad. Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.
1843 ...	0·56	21·26	21·82[1]	...	...	...	...	...	...
1844 ...	3·25	32·59	35·84	0·00	41·04	42·00	...	...	...
1845 ...	2·07	31·21	33·28	5·17	43·11	48·28	...	...	...
1846 ...	1·40	30·70	38·28	1·21	37·63	38·77	...	...	...
1847 ...	4·05	43·48	47·53	2·83	52·70	55·53	...	...	...
1848 ...	0·35	37·00	37·35	?	61·15	?	...	...	...
1849 ...	1·90	24·25	26·15	1·25	23·53	24·78	...	...	...
1850 ...	1·95	35·20	37·15	2·48	?	?	...	...	...
1851 ...	2·30	44·50	46·80	4·50	32·50	37·00	...	...	...
1852 ...	2·80	?	?	...	...	...	...	...	...
1853 ...	...	...	...	...	...	...	...	...	...
1854 ...	...	...	...	...	...	...	...	...	...
1855 ...	...	...	...	...	...	...	...	...	...
1856 ...	...	...	...	...	...	...	...	...	...
1857 ...	...	...	...	...	...	...	...	...	...
1858 ...	...	...	...	...	...	...	...	...	...
1859 ...	...	...	...	...	...	...	...	...	...
1860 ...	0·40	20·13	20·53	...	...	...	...	...	...
1861 ...	2·10	58·20	60·30	?	50·4	?	?	37·8	?
1862 ...	1·25	32·10	33·35	1·6	42·1	43·7	1·4	50·4	51·8
1863 ...	0·40	36·75	37·15	0·5	18·5	19·0	0·0	31·0	31·0
1864 ...	0·82	41·10	41·92	1·4	18·0	19·4	0·5	15·2	15·7
1865 ...	5·05	31·75	36·80	2·4	33·5	35·9	4·0	35·3	39·3
1866 ...	4·80	40·75	45·55	1·7	26·4	28·1	1·0	23·2	24·2
1867 ...	...	...	...	1·19	43·50	44·69	2·6	47·0	49·6
1868 ...	2·93	29·81	32·74	·67	30·56	31·13	0·8	21·0	21·8
1869 ...	0·72	36·71	37·43	·78	33·09	33·87	0·3	15·3	15·6
1870 ...	1·01	69·71	70·72	·93	45·27	46·20	0·9	62·7	63·6
1871 ...	1·44	56·58	58·02	3·25	51·89	55·14	1·5	57·4	58·9
1872 ...	2·56	38·70	41·26	2·05	31·68	33·73	3·5	40·5	44·0
1873 ...	1·67	36·05	37·72	0·22	35·87	36·09	1·1	31·3	32·4
1874 ...	2·30	57·29	59·59	0·44	62·44	62·88	0·50	39·90	40·40
1875 ...	1·52	44·99	46·51	1·46	43·36	44·82	0·17	51·26	51·43
1876 ...	0·57	53·73	54·30	0·07	24·69	24·76	0·00	28·50	28·50
1877 ...	2·83	30·05	32·88	5·68	21·69	27·37	5·07	16·24	21·31

Years.	5. Jabalpur. Winter.	5. Jabalpur. Summer.	5. Jabalpur. Total.	6. Delhi. Winter.	6. Delhi. Summer.	6. Delhi. Total.	7. Ambala. Winter.	7. Ambala. Summer.	7. Ambala. Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.
1843 ...	...	...	...	...	...	...	...	...	...
1844 ...	?	23·16	?	?	11·59	?	...	...	...
1845 ...	3·18	41·44	44·62	3·28	20·40	23·68	...	...	...
1846 ...	0·77	67·78	68·55	0·74	20·18	20·92	...	...	...
1847 ...	0·61	44·35	44·96	2·87	25·81	28·68	...	...	...
1848 ...	0·15	34·97	35·12	0·77	13·54	14·31	...	...	...
1849 ...	3·29	43·63	46·92	4·99	20·64	25·63	...	...	...
1850 ...	1·40	43·19	44·59	4·35[2]	...	...	...	...	...
1851 ...	1·42	37·12	38·54	6·16[2]	...	...	...	...	...
1852 ...	3·87	72·18	76·05	...	...	...	?	36·4	?
1853 ...	1·50	58·30	59·80	...	...	...	2·5	27·5	30·0
1854 ...	6·01	46·18	52·70	...	...	...	4·4	37·9	42·3
1855 ...	5·86	51·21	57·07	...	...	...	5·6	22·0	27·6
1856 ...	3·19	40·17	43·06	...	...	...	1·2	40·1	41·3
1857 ...	0·49	50·60	51·09	...	...	...	3·8	27·7	31·5
1858 ...	0·12	39·90	40·02	...	...	...	3·5	33·5	37·0
1859 ...	2·11	46·90	49·01	?	27·10	?	9·1	21·8	30·9
1860 ...	0·00	49·35	49·35	1·7	41·8	43·5	3·5	29·6	33·1
1861 ...	2·90	42·13	45·03	1·8	23·2	25·0	3·3	29·0	32·3
1862 ...	1·95	37·15	39·10	0·0	60·4	60·4	2·7	33·1	35·8
1863 ...	1·00	59·45	60·45	3·8	33·0	36·8	4·3	53·5	57·8
1864 ...	3·10	42·03	45·13	4·0	23·7	27·7	5·1	24·1	29·2
1865 ...	5·41	54·71	60·12	3·2	26·5	29·7	11·7	37·0	48·7
1866 ...	0·85	62·26	63·11	3·1	32·7	35·8	13·0	22·8	30·7
1867 ...	1·67	71·43	73·10	3·2	19·8	23·0	0·7	37·6	38·3
1868 ...	5·27	23·53	28·80	4·2	3·9	8·1	9·3	10·5	19·8
1869 ...	0·22	62·55	62·77	1·0	22·5	23·5	7·6	20·7	28·3
1870 ...	2·71	75·07	77·78	3·2	21·0	24·2	5·1	30·2	35·3
1871 ...	2·00	57·22	59·22	3·2	29·0	·2	5·0	33·5	38·5
1872 ...	3·50	63·69	67·19	3·6	20·1	·7	2·6	48·4	51·0
1873 ...	0·94	45·17	46·11	1·2	33·0	34·2	1·8	41·9	43·7
1874 ...	0·64	58·39	59·03	1·9	20·4	22·3	3·4	37·2	40·6
1875 ...	0·39	61·25	61·63	1·3	36·9	38·2	3·3	30·5	33·9
1876 ...	0·00	56·63	56·63	1·1	17·5	18·6	1·0	28·9	29·6
1877 ...	9·83	43·39	53·22	7·5	10·1	17·6	13·4	10·3	23·7

Years.	8. Lahore. Winter.	8. Lahore. Summer.	8. Lahore. Total.	9. Gujranwala. Winter.	9. Gujranwala. Summer.	9. Gujranwala. Total.	10. Shahpur. Winter.	10. Shahpur. Summer.	10. Shahpur. Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.
1843 ...	...	...	...	...	...	...	...	...	...
1844 ...	...	...	...	...	...	...	...	...	...
1845 ...	...	...	...	...	...	...	...	...	...
1846 ...	...	...	...	...	...	...	...	...	...
1847 ...	...	...	...	...	...	...	...	...	...
1848 ...	...	...	...	...	...	...	...	...	...
1849 ...	...	...	...	...	...	...	...	...	...
1850 ...	...	...	...	...	...	...	...	...	...
1851 ...	...	...	...	...	...	...	...	...	...
1852 ...	...	...	...	...	...	...	...	...	...
1853 ...	...	...	...	...	...	...	...	...	...
1854 ...	...	...	...	?	16·1	?	...	...	...
1855 ...	...	...	...	9·2	16·2	25·4	?	13·1	?
1856 ...	...	...	...	1·8	22·1	23·9	4·2	19·7	23·9
1857 ...	...	...	...	6·4	12·6	19·0	5·4	11·4	16·8
1858 ...	...	...	...	2·5	18·7	21·2	2·0	9·0	11·0
1859 ...	...	...	...	5·5	15·9	21·4	4·5	6·0	10·5
1860 ...	...	...	...	3·2	14·2	17·4	2·2	8·3	10·5
1861 ...	...	...	...	3·0	24·0	27·0	4·7	10·8	15·5
1862 ...	?	17·3	?	3·6	25·3	28·9	4·4	20·2	24·6
1863 ...	3·2	23·2	26·4	4·3	23·4	27·7	3·2	13·2	16·4
1864 ...	2·4	10·0	12·4	5·2	16·0	21·2	3·9	7·7	11·6
1865 ...	7·0	17·0	24·0	10·4	21·9	32·3	9·6	9·8	19·4
1866 ...	1·1	16·1	17·2	1·9	31·8	33·7	3·3	7·6	10·9
1867 ...	3·3	16·8	20·1	3·7	24·4	28·1	5·0	9·0	14·0
1868 ...	7·8	7·3	15·1	9·6	15·4	25·0	9·7	4·1	13·8
1869 ...	4·0	15·9	19·9	7·2	22·0	29·2	9·0	11·7	20·7
1870 ...	1·0	8·2	9·2	3·3	16·1	19·4	3·6	8·5	12·1
1871 ...	2·4	6·3	8·7	1·9	10·2	12·1	1·9	10·4	12·3
1872 ...	3·1	14·0	17·1	7·1	19·8	26·9	2·6	22·0	24·6
1873 ...	1·3	24·0	25·3	1·3	21·8	23·1	2·6	11·7	14·3
1874 ...	3·9	11·3	15·2	5·9	14·1	20·0	2·3	12·3	14·6
1875 ...	2·6	30·6	33·2	2·3	16·9	19·2	3·3	7·7	11·0
1876 ...	1·5	20·0	21·5	6·1	27·0	33·1	4·9	11·3	16·2
1877 ...	12·2	4·8	17·0	19·3	3·9	23·2	13·0	5·0	18·0

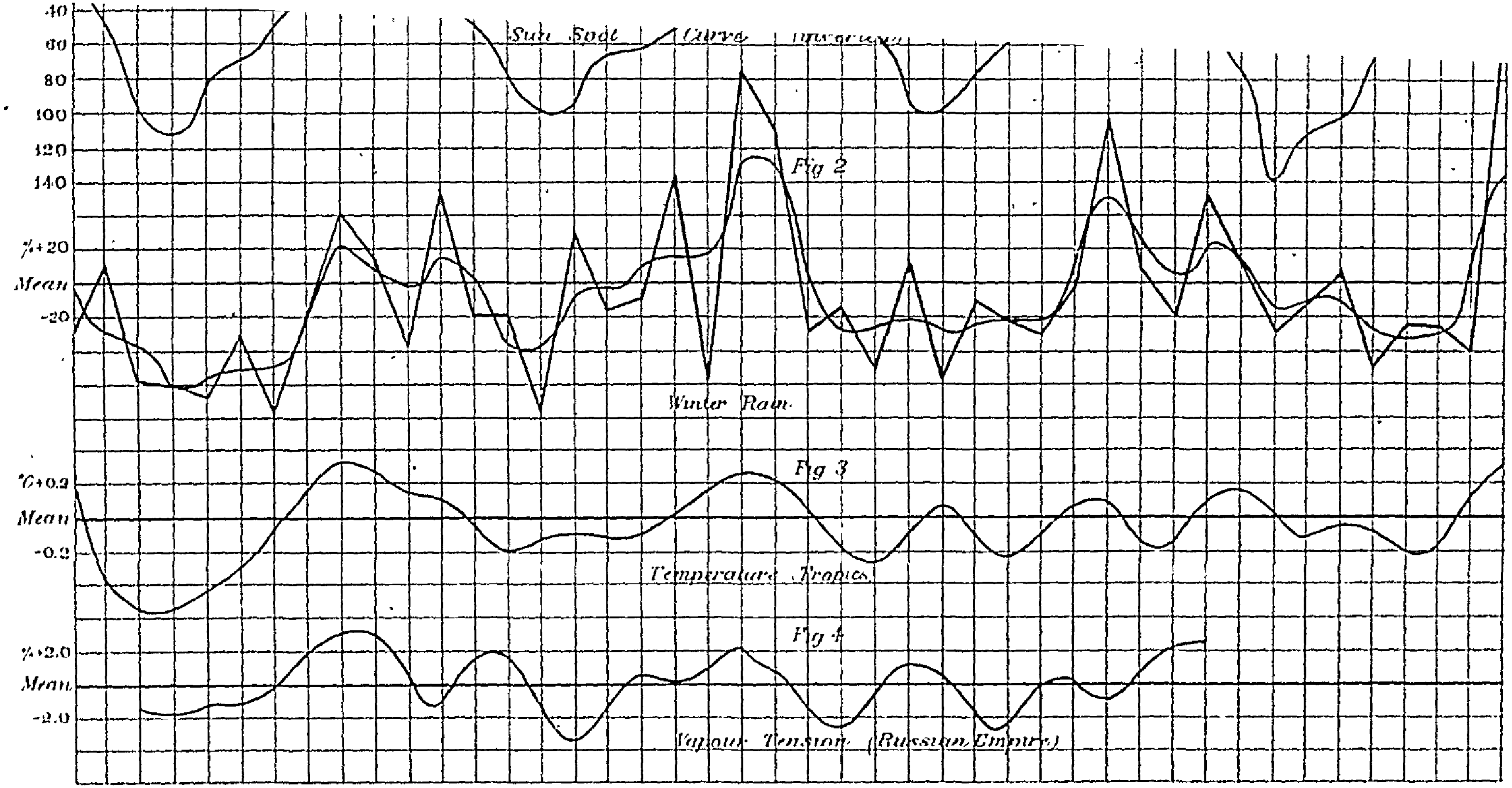
[1] The figures in antique are taken from the Patna register.

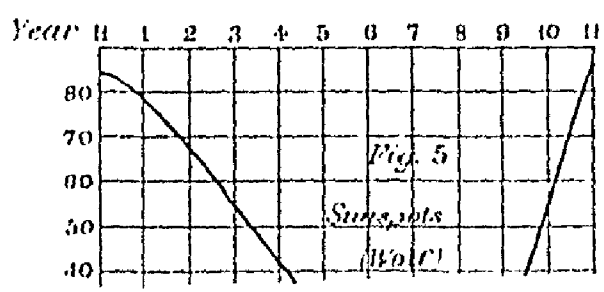
[2] November and December wanting. These months are nearly rainless.

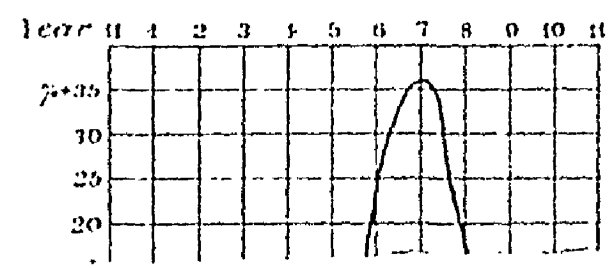
Rainfall Tables—concluded.

Years.	11. Bannu.			12. Peshawar.			13. Abbottabad.			14. Rawalpindi.			15. Dharmsala.			16. Simla.			17. Dehra.			18. Naini Tal.			19. Darjiling.			20. Sibsagar.		
	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.	Winter.	Summer.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1837 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6·84	115·42	122·26	...	...	...
1844 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1845 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1846 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1847 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1848 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1849 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	25·30	57·07	83·33
1850 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	24·07	70·41	94·48
1851 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3·00	33·61	36·61	...	...	...	...	...	...	9·30	113·20	122·50	14·66	68·39	83·05
1852 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1853 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1854 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1855 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1856 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1857 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1858 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1859 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1860 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4·16	115·95	120·11	...	...	...
1861 ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2·0	96·1	98·1	1·4	?	?	[2]4·28?	145·95	150·23	[1]14·01	53·59	67·60
1862 ...	?	6·8	?	?	2·7	?	?	21·0	?	?	20·2	?	?	139·1	?	?	91·9	?	3·9	91·5	95·4	?	117·3	?	0·60	?	?	[1]15·33	67·13	82·46
1863 ...	2·2	20·9	23·1	5·3	5·2	10·5	14·1	28·8	42·9	8·6	29·1	37·7	17·8	124·6	142·4	7·6	61·4	69·0	3·4	74·9	78·3	10·4	53·7	64·1	...	...	...	15·40	83·60	99·00
1864 ...	6·2	6·8	13·0	9·3	3·2	12·5	22·5	28·5	51·0	11·3	27·6	38·9	24·8	62·2	87·0	21·4	73·5	94·9	5·4	50·4	55·8	3·2	47·2	50·4	...	...	...	21·60	96·00	121·70
1865 ...	6·3	6·2	12·5	13·3	3·9	17·2	32·0	21·0	53·0	12·5	16·3	28·8	36·5	81·3	117·8	23·1	56·2	79·3	18·0	65·1	83·1	29·3	70·0	99·3	...	...	...	25·40	50·50	75·90
1866 ...	4·9	7·5	12·4	9·6	3·2	12·8	13·2	22·1	35·3	9·4	14·7	24·1	12·5	85·7	98·2	8·4	58·4	66·8	8·7	67·1	75·8	13·1	61·3	74·4	...	...	...	12·40	59·80	72·20
1867 ...	5·2	11·1	16·3	2·0	3·9	5·9	18·5	30·6	49·1	8·5	12·8	21·3	16·0	157·8	173·8	6·3	45·8	52·1	4·7	62·7	67·4	8·1	88·6	96·7	...	...	...	[1]16·93	72·77	89·70
1868 ...	14·4	3·9	18·3	10·7	1·9	12·6	27·3	17·5	44·8	8·6	14·8	23·4	31·1	78·4	109·5	11·8	49·5	61·3	11·4	41·7	53·1	17·5	71·9	89·4	6·41	128·93	135·34	[1]26·27	62·73	89·00
1869 ...	5·3	6·5	11·8	6·2	10·3	16·5	25·6	24·9	50·5	17·4	10·4	27·8	30·7	103·9	134·6	12·1	45·9	58·0	11·9	70·5	82·4	16·0	62·6	78·6	7·40	93·18	100·58	19·00	84·30	103·30
1870 ...	1·4	4·8	6·2	3·9	4·3	8·2	8·3	24·7	33·0	2·3	27·7	30·0	20·1	158·4	178·5	16·2	53·0	69·2	7·6	77·5	85·1	7·5	98·7	106·2	10·34	136·38	146·72	10·96	87·65	98·61
1871 ...	3·3	7·0	10·3	7·5	3·7	11·2	18·4	31·7	50·1	7·4	21·1	28·5	18·9	175·5	194·4	3·7	70·2	73·9	3·9	102·7	106·6	15·0	81·5	96·5	7·40	109·60	117·00	23·79	97·28	121·07
1872 ...	5·1	4·7	9·8	6·4	10·0	16·4	21·9	47·9	69·8	12·3	18·0	30·3	16·7	141·7	158·4	7·9	54·3	62·2	11·4	70·1	81·5	12·6	102·0	114·6	6·36	101·10	107·46	26·80	76·87	103·67
1873 ...	2·9	6·1	9·0	6·3	5·6	11·9	11·4	25·8	37·2	6·1	22·6	28·7	13·5	107·2	120·7	9·7	54·5	64·2	8·5	58·3	66·8	7·4	43·5	50·9	7·82	69·34	77·16	19·66	53·61	73·27
1874 ...	5·3	14·1	19·4	6·8	8·3	15·1	14·2	25·6	39·8	10·0	31·1	41·1	29·1	130·2	159·3	9·3	44·9	54·2	11·2	89·0	100·2	6·2	90·2	96·4	8·85	116·15	125·00	24·69	101·56	126·25
1875 ...	5·9	10·3	16·2	7·1	11·5	18·6	18·8	37·3	56·1	8·9	39·9	48·8	15·6	141·1	156·7	6·3	72·8	79·1	6·4	71·4	77·8	8·7	74·5	83·2	7·11	108·06	115·17	33·07	70·21	103·28
1876 ...	5·0	7·3	12·3	9·2	0·9	10·1	13·9	38·4	52·3	14·2	21·3	35·5	14·2	126·1	140·3	8·1	67·6	75·7	2·9	76·8	79·7	4·1	64·5	68·6	3·15	113·18	116·03	17·57	66·16	83·73
1877 ...	15·1	6·7	21·8	24·1	0·4	24·5	42·8	26·5	69·3	27·7	11·9	39·6	43·2	53·4	96·6	29·5	37·3	66·8	13·80	22·60	36·40	28·5	40·5	69·0	11·74	91·57	103·31	18·68	74·01	92·69

[1] The figures in antique are supplied from the Register of the adjacent station Nazira'h.
[2] November wanting.


Sun Spot Curve (inverted)
Fig 2
Winter Rain
Fig 3
Temperature Tropics
Fig 4
Vapour Tension (Russian Empire)
40
60
80
100
120
140
%+20
Mean
-20
°C+0.2
Mean
-0.2
%+2.0
Mean
-2.0


Year 11 1 2 3 4 5 6 7 8 9 10 11
80
70
60
50
40
Fig. 5
Sunspots
(Wolf)


Year 11 1 2 3 4 5 6 7 8 9 10 11
%+35
30
25
20

VIII.—Meteorological and hypsometrical observations in Western Tibet, recorded by Dr. J. Scully; *with a discussion by* H. F. Blanford, *Meteorological Reporter to the Government of India.*

In the detailed notice of Dr. Scully's observations in Yárkand and Káshghár, given in a previous part of this volume, it was mentioned that during the journeys of Mr. Shaw's mission to and from Yárkand, a series of very careful and elaborate observations were recorded by Dr. Scully and his assistants; and that, on the return journey more especially, precautions were taken to ensure uniformity in the exposure of the thermometers, by means of a portable thermometer shed, which effectually protected the instruments from sky-radiation, while it allowed of their free exposure to the air, and afforded conditions as nearly as possible identical with those observed at Yárkand and generally at meteorological stations in India. The observations recorded on the return journey are furthermore of superior value, in that the travellers were less hurried, and were enabled to make longer halts at their camping places than on the outward journey; the two routes being almost identical. The later readings are therefore more numerous and regular, as well as more complete in kind; in the case of most stations, they comprise a complete diurnal series recorded at intervals of six hours; and for seven stations, at which more prolonged halts were made, they include also hourly readings of the principal instruments. These observations, reduced and corrected for the errors of the instruments, are here given in full. The less extensive and regular series, registered on the outward journey, will be noticed as occasion may require, in the course of the discussion. The barometric observations, more especially, have been utilised in conjunction with those of the return journey, for determining the elevations of the several camping places; and, in the Appendix, a comparison is made between them and the readings of boiling point thermometers simultaneously recorded, which affords a useful experimental test of the practical trustworthiness of the latter instrument in hygrometrical measurements.

The route of the travellers lay across some of the highest accessible ground of Central Asia. For five days, they journeyed at elevations scarcely ever below 16,000 feet, traversing the high tableland that separates the valleys of the Kárákásh and the Shayok. Brief as are, of necessity, the registers furnished for this inhospitable tract, they are of unusual interest, and suffice to throw some light on the diurnal variation of temperature and pressure, and also on the course of the air currents on these elevated plains, where the air is attenuated to little more than half its sea-level density, and where the sacrifice of life is but too often the penalty paid by the explorer.[1]

[1] It was the exertion of traversing this plateau that brought poor Stoliczka's life to a premature close. And it is likely that the ominous name of the camp below the Karakoram, Daulat Beg Uldi, "Daulat Beg died," is the record of some similar catastrophe in days gone by.

Before entering on the discussion of the meteorological registers, it will be useful to premise a short sketch of the geographical features of the route,[1] for the details of which I am indebted partly to Dr. Bellew's itinerary, partly to Dr. Scully's own description,[2] and the verbal communications of Mr. R. B. Shaw.

Geography of the route.—From Yárkand to near Karghalik, the route lay across the plain of Káshghár, well cultivated, thickly covered with farmsteads, and traversed by numerous irrigation streams. In the neighbourhood of the latter place, the cultivation becomes thinner and interspersed with larger patches of marsh and waste, with saline encrustations; and beyond it, the road enters on the dry gravelly or stony slopes which fringe the base of the mountains, and present a bare desert surface, interrupted by an occasional river channel, the hollow of which is an oasis of verdure. In these latter, are situated the halting-places at the end of each stage. Crossing these slopes, and gradually ascending and approaching the mountains, the road at length reaches Sanju, a large populous town, situated in a depression about 600 feet below the level of the terrace which extends outwards from the foot of the mountains. From this stage, the ascent becomes more rapid, and the road enters the hills, following the course of one of the streams which flow into the Sanju depression. The next halting-place, Kizil Aghil, is similar in position to Sanju, but more within the hills; and hence the road threads the narrowing valley, up to the Chuchu Pass. Crossing this, a rapid descent leads down to the upper part of the Sanju stream, which here flows in a narrow rocky gorge in which is situated Tadlik. Soon after leaving this place, the road rises rapidly, leading up through a widening defile, which opens out into the grassy alpine slopes of Kichik Yailak, nearly 12,000 feet above the sea. At this camping place, the travellers halted for a day; and the opportunity was seized by Dr. Scully to record a complete diurnal series of hourly readings of his instruments, which, in virtue of the position, are of unusual interest. From Kichik Yailak, a further ascent of nearly 5,000 feet leads up to the crest of the Sanju Pass, about 16,500 feet above sea-level. The travellers may now be considered to have fairly entered on the mountain tract. After leaving Tadlik, until two stages beyond Leh, they were never at a lower elevation than 10,000 feet. From the Sanju Pass, they descended into the valley of the Kárákásh river; which was reached 5 miles beyond Baz Chat, through the narrow defile which leads down from the pass, and in which Baz Chat is situated.

From this point, the route, for the next five stages, lay up the valley of the Kárákásh, ascending gradually from 10,000 to 13,000 feet, and skirting the northern base of the great Kárákoram plateau[3]. On the outward journey, the travellers had descended from the plateau through the Suget Pass, which leads down into the Kárákásh valley, three stages below the point at which they quitted it on their return. On the latter occasion, they followed it up to Portash or Fotash; halting, however, for four days at Gulgan Shah Mazar, in order to feed up the horses, and prepare them to face the trying march across the barren Kárákoram plateau. This halt, like the former at Kichik Yailak, was taken advantage of, to obtain a series of hourly readings of the meteorological instruments.

The camp of Portash is situated at the head of a small side valley leading into that of the Kárákásh. From this point begins the ascent to the plateau, over a

[1] Report of Forsyth's Mission to Yarkand in 1873, p. 421.

[2] Stray Feathers, Vol. IV, pp. 1 *seq.*

[3] I learn from Mr. R. B. Shaw that he has proposed this name as a general name for the plateau between the Shayok and the Kárákásh. It was much required.

series of moraines, and then up a broad flat-looking valley with low bare hills on either side. The ascent is so gradual that, as Dr. Scully observes, it was difficult to determine the highest point of this very easy pass. His barometric observations give it an elevation of nearly 17,000 feet; and thence a short but steep descent of not more than 500 feet, leads down to the camping-place of Baluk Bachi, or Akin. The next stage is Durwaza Sarighot, on a high tableland; it gives its name to all that part of the plateau that lies north of the Kárákoram pass; and derives it from the scanty yellowish grass which grows about, and affords the best fodder to be found in this inhospitable region. From this, the ground slopes gently to the Kárákoram, which is the watershed of the plateau; an apparently low and inconspicuous ridge, as seen from this post of vantage. The road leads up "a wide, shallow, shingly, drainage bed, between low banks of shale, that roll away in wide sweeps to the mountain tops," and beyond Balti Brangsa (or Brangsa Kárákoram) enters a narrow gorge, and then a wider gully which rises gradually to the pass. Dr. Scully remarks that "the Kárákoram Pass reminded one much more of a short embankment, 300 feet or so above the level of the surrounding country, than what one understands by a *mountain pass*", and adds: "I certainly did not see anything like a range." On the south, the descent is a little more rapid than on the north, but still very gentle, down another wide shingly valley, which narrows somewhat towards the camping-place of Daulat Beg Uldi. This is situated in a wide valley "covered with bare gravel," and traversed by a shallow stream, running westwards; which is, in fact, the upper part of the Shayok river. Instead, however, of following down this watercourse, the road ascends to the high Dipsang plain, "an immense undulating plain, which," says Dr. Scully, "looked like the top of the world. The plain was gravelly, and seemed to slope gently eastwards towards some low hills in that direction; northwards, in front of us, we saw a few irregular flat-topped hillocks (they looked like) scattered about; to the left, the clear blue sky appeared to be the only boundary of our plain; and to the south-west the distant tops of some fine snowy peaks peeped up above our level"; to the south "a fine snowy range of mountains met my view, and looked quite continuous; but of course this was a deceptive appearance." This last is the prolongation of the Mustágh range, which, though not the watershed of the region, appears to be the most elevated and conspicuous range of this part of Tibet.

Crossing the Dipsang plain, the road descends through a stony ravine to the camping ground at Kizil Ungur; and thence across a gravel-covered plain to that of Burtse, so called from a species of *Eurotia* which grows about it, and which is the sole vegetation of this desolate region. Both this and the next camping-place, Murgha, are situated in the uppermost part of valleys that begin to descend from the Dipsang, to debouch and unite in the main valley of the Shayok. Sasser or Brangsa Saser is situated in this valley, on a gravelly terrace, about 400 feet above the level of the stream. Up to this halting-place, the line of road has descended but little below 15,000 feet. From Brangsa Saser it ascends the ridge between the Upper Shayok and its tributary the Núbra river, crossing it by the Sasser Pass at an elevation of 17,600 feet nearly. This pass, says Dr. Scully is, "totally unlike any other which I have been over; instead of being the lowest part of a ridge of mountains, the Sasser Pass seemed to me to be made up of a rather complicated knot of glaciers and their moraines, which had met at one point and jammed up against each other." And Dr. Bellew describes the road as passing

"up a rough gully and across a glacier at its watershed, for two or three miles; then up and down by an extremely difficult path, between the side of the glacier and the opposite hills, a narrow pass full of angular rocks and snowdrifts, and in summer, purling with torrents on all sides." Sartang camping-ground, below the pass, is "an open space, menaced by half a dozen glaciers around."

After a slight descent into the upper part of the Sasser valley, to the camping-place of Toti Yailak, at upwards of 15,000 feet, the road follows the river down for three miles, and then again rises to cross the Káráwal Diwán or pass, from which it descends rapidly into the Núbra valley, "the first green spot and inhabited country met with since Sanju." Chang Lung, the next camping place, and the three following, *viz.*, Panamik, Taghar, and Tsatti, are all situated in the Núbra valley, at elevations between 10,000 and 11,000 feet; lower therefore than Leh.

From Tsatti to Leh, the travellers took the alternative route of the Khardong Pass, nearly 18,000 feet, to cross from the Shayok into the parallel valley of the Indus.

The remainder of the route is through a well-known country, and may be dismissed with a cursory notice. The first three marches are down the Indus valley, bringing the travellers down to an elevation of 9,000 feet at Nurla. The road then begins to ascend the mountain chain to the south, and crossing the Foto and Namika Passes into the Dras valley, a tributary of the Indus, finally crosses the Zogi La into the Sind valley, which leads down into the plain of Srinagar. The final stages of the journey are on the well-known route between the old Kashmir capital and the Punjab hill station of Murree.

Elevations.

The elevations, given in the second column of the table, have been arrived at in the following manner. All the observations of the mercurial barometer recorded at one and the same station, whether on the outward or homeward journey, were reduced and corrected, and the mean of the whole was taken as the pressure datum for the station. In like manner, the temperature readings of the dry-bulb thermometer, recorded at the same hours, were corrected for the error of the instrument, and their mean assumed as the mean temperature of the air. A mean pressure and temperature at Leh (the reference station) was then found by a similar process. But since the barometer and thermometer at that station were read only at 10*h.* and 16*h.*, and these together with the maximum and minimum temperatures of each day constitute the whole available data, it was necessary to find interpolated values for some of the hours corresponding to those of the traveller's readings. For this purpose, I have utilised the hourly readings which have been recorded at Leh, on four days in each month, during the last two years. From these were deduced the approximate hourly variations both of temperature and pressure; and in applying the appropriate corrections, it was assumed that any difference of range (in excess or defect of that shewn by the hourly observations) should be equally distributed in the interval of the two consecutive observations. In the case of temperature, the minimum has been assumed to occur at the normal hour of minimum temperature in each month.

From Yárkand to Leh, the number of readings of the instruments recorded at each station and utilised in deducing the elevations, are shewn in the following table; the table gives also the mean pressures and temperatures, and the difference of elevation deduced by process above described.

The difference of elevation has been computed with Captain Allan Cunningham's tables, which gives the value of the logarithm of a in the formula—

$$Z = \frac{\log. H - \log. h}{a}$$

wherein, Z is the required difference of elevation; H and h the barometric readings at the reference station and the station of observation respectively; and a the tabular value computed by the formula—

$$a = \frac{1}{60360\left(1 + \frac{T + t - 64}{986}\right)}$$

for the several values of $T + t$ (the air temperatures of the two stations). I have added 150 feet to the computed elevations of stations to the north of the Sanju Pass, to allow for the annual oscillation of pressure between Leh and Yárkand, the evidence of which is afforded by the table in a footnote at page 42.

Table of hypsometrical elements.

	Station.	Readings at Station.	Readings at Leh. Obs.	Readings at Leh. Interp.	Mean Bar. at Station.	Mean temp. at Station.	Mean Bar. at Leh.	Mean temp. at Leh.	Computed difference of elevation.	Computed elevation above S. L.
					Ins.	° Fahr.	Ins.	° Fahr.	Feet	Feet
Plains of Yarkand.	Yangaklik	3	1	2	25·528	78·	19·566	62·9	−7,516	4,137
	Igarchi	4	2	2	·530	80·8	·551	62·7	−7,559	4,094
	Posgam	7	3	4	·448	70·4	·585	60·4	−7,330	4,323
	Yakshamba Bazar... ...	5	2	3	·388	78·	·530	63·6	−7,417	4,236
	Karghalik	20	8	12	·369	71·4	·598	59·3	−7,224	4,429
On Fans of Talus chiefly desert.	Basharik	5	2	3	·286	77·3	·616	63·8	−7,176	4,477
	Bora	6	2	4	24·565	67·8	·616	58·1	−6,269	5,384
	Oi Toghrak	7	3	4	·177	72·5	·670	57·0	−5,768	5,885
	Koshtak	5	1	4	·073	63·6	·637	51·8	−5,681	5,972
	Salik Aziz Langar ...	7	2	5	·022	56·9	·669	49·0	−5,460	6,193
Sanju Valley.	Sanju	26	10	16	23·727	63·7	·663	52·4	−5,185	6,468
	Kizil Aghil	3	1	2	·178	51·3	·587	51·2	−4,585	7,068
	Khuda Berdi Mazar ...	4	1	3	22·125	53·8	·655	57·0	−3,250	8,403
	Chuchu Diwan Pass ...	2	1	1	19·564	38·	·629	56·7	+89	11,592
Sanju Valley.	Chong Tash	3	1	2	22·005	49·4	·675	57·7	−3,062	8,591
	Tadlik	7	2	5	21·147	50·1	·625	55·8	−2,041	9,612
	Kichik Yailak	11	4	7	19·398	39·	·647	54·7	+344	11,847
	Sanju Pass	3	1	2	16·391	28·6	·727	60·6	+4,280	16,183
	Baz Chat	3	1	2	18·843	38·2	·669	52·1	+1,155	12,658
Karakash Valley.	Kurghan Ali Nazar ...	7	2	5	20·352	51·0	·683	56·9	−916	10,587
	Toghrasu	7	1	6	19·959	47·7	·703	49·7	−350	11,153
	Oibuk	11	4	7	·560	59·	·652	62·3	+130	11,633
	Balakchi	5	2	3	·297	60·1	·560	66·8	+378	11,881
	Gulgan Shah Mazar ...	23	8	15	·144	50·1	·674	60·1	+749	12,252

150 feet have been added to the elevation, as barometrically determined, to compensate for the summer barometric depression of Yárkand shown by the table in the footnote on page 42.

Table of hypsometrical elements,—continued.

	Station.	Readings at Station.	Readings at Leh. Obs.	Readings at Leh. Interp.	Mean Bar. at Station.	Mean temp. at Station.	Mean Bar. at Leh.	Mean temp. at Leh.	Computed difference of elevation.	Computed elevation above S. L.
					Ins.	° Fahr.	Ins.	° Fahr.	Feet.	Feet.
Karakoram Plateau.	Portash	5	2	3	18·517	55·8	19·696	61·7	+1,706	13,209
	Highest Pass of Portash ...	2	1	1	16·169	45·6	·652	65·4	+5,358	16,861
	Balak Bachi, or Akin ...	2	0	2	·369	29·5	·664	47·6	+4,872	16,375
	Durwaza Sarighot ...	5	1	4	·759	30·9	·683	51·2	+4,293	15,796
	Balti Brangsa	4	2	2	·188	38·3	·710	55·7	+5,318	16,821
	Karakoram Pass	3	1	2	15·350	33·5	·686	62·	+6,730	18,233
	Daulat Beg Uldi	4	0	4	16·323	24·	·697	45·7	+4,954	16,457
	Highest Pass of Dipsang ...	2	1	1	15·636	34·7	·725	60·3	+6,281	17,781
	Burtse	5	1	4	16·891	33·9	·651	49·1	+4,043	15,546
Shayok valley.	Murghu	8	3	5	17·369	49·8	·615	59·8	+3,336	14,839
	Sasser ...	7	3	4	·194	48·	·658	57·2	+3,657	15,160
	Sasser Diwan	4	1	3	15·722	30·4	·697	62·5	+6,082	17,585
	Toti Yailak	2	0	2	17·003	38·	·637	49·2	+3,864	15,367
	Karawal Diwan	2	0	2	·230	52·1	·666	67·5	+3,662	15,165
Nubra valley.	Chang Lung	5	1	4	20·063	61·8	·591	58·1	−660	10,843
	Panamik	10	4	6	·323	64·	·639	55·1	−948	10,555
	Taghar	6	2	4	·580	52·1	·639	47·9	−1,272	10,231
	Tsatti	6	1	5	·436	56·2	·779	49·3	−893	10,610
	Below Khardong	4	1	3	17·125	39·3	·875	52·7	+4,015	15,518
	Khardong Pass	4	1	3	15·723	39·1	·804	63·1	+6,283	17,786
Indus valley.	Leh	...	...	...	...	...	...	...	...	11,503
	Nimu	2	0	2	20·565	51·6	·765	45·6	−1,075	10,428
	Saspol	3	1	2	·657	64·6	·735	54·5	−1,264	10,239
	Nurla	4	2	2	21·667	63·4	·731	57·9	−2,596	8,909
	Lama Yuru	4	2	2	19·827	51·6	·680	54·6	−203	11,300
	Foto Pass	2	1	1	18·389	49·9	·655	50·7	+1,810	13,313
	Bod Kherbo	3	1	2	19·739	51·8	·629	46·7	−152	11,351
	Namika Pass	2	1	1	18·971	48·1	·691	52·4	+1,013	12,516
	Shergol	5	1	4	20·439	49·5	·685	36·3	−1,007	10,496
Dras valley.	Karghil	3	1	2	21·775	54·6	·734	41·4	−2,664	8,839
	Kherbo of Dras	2	0	2	·466	51·4	·756	37·6	−2,231	9,272
	Dras	3	1	2	20·712	55·1	·674	46·9	−1,400	10,103
	Matain	4	2	2	·317	52·4	·619	49·1	−951	10,552
Sind valley.	Zogi Pass	2	1	1	19·802	48·1	·663	56·	−192	11,311
	Baltal	3	1	2	21·253	45·1	·627	47·3	−2,147	9,356
	Shita Kari	4	2	2	22·037	42·2	·652	47·5	−3,081	8,422
	Kolan	4	2	2	23·144	44·1	·678	41·6	−4,347	7,156
	Kanggan	4	2	2	24·285	51·4	·652	44·1	−5,726	5,777
	Gundar Ral	4	2	2	·853	48·5	·599	42·	−6,394	5,109

On comparing the elevations of the foregoing table with those deduced by Captain Trotter, from his readings, partly of the barometer, partly of the boiling point thermometer, it is to be remarked that, in the former, all the stations on the Kárákoram plateau, indeed, all between the Kárákásh and the Núbra valley, are about 300 feet lower than Captain Trotter's determinations. In some other cases, chiefly in Yárkand, the present results are the highest. The reason of this probably lies chiefly in the difference of the reducing formulæ used by Captain Trotter and myself. Although I do not find it actually stated in his report, I have reason to believe that he has employed the formula given in Cape's Course of Mathematics, Vol. II, in which the co-efficient of expansion of air is taken at $\frac{1}{480}$ for each degree Fahrenheit; whereas in the formulæ used in the present reductions, that co-efficient is taken at $\frac{1}{493}$ of the volume at the freezing point. It is very likely that, in some cases, such as that of Portash camp, the sites selected were not identical.

Fig. 1, Plate XV, gives a graphic representation of the hypsometrical data, the horizontal scale being 16 miles to 1 inch, the vertical scale 10,000 feet to 1 inch.

Meteorological observations.

These, as recorded on the return journey, comprise the readings of the following instruments:—

1. *Solar maximum thermometer in vacuo.*—A mercurial thermometer on Phillips' self-registering principle, with a small spherical bulb coated with lampblack, the thermometer being enclosed in a large tube exhausted and hermetically sealed. It was placed on forked supports about 3 feet above the ground. The readings of this instrument are uncorrected.

2. *Minimum spirit thermometer for nocturnal radiation.*—This was exposed at night, on the ground, either on grass or on wool. The readings are corrected for the error of the instrument.

3. *Dry and wet bulb mercurial thermometers.*

4. *Maximum mercurial thermometer* for shade temperatures, on Phillips' principle.

5. *Minimum spirit thermometer* for shade temperatures.

6. *Wet bulb minimum spirit thermometer.*—With the exception noticed, all the above instruments were verified with a Kew standard and in melting ice, after the return of the Mission, and the proper corrections have been applied to their readings. The shade thermometers and hygrometers were exposed under a portable shed of felt, supported by a framework of rods;[1] and the readings are therefore comparable with those recorded at the permanent observatories in India, and those previously registered by Dr. Scully in Káshghár.

7. *A barometer* on Fortin's principle, by Messrs. Troughton and Sims, No. 910, with a tripod stand, made light and portable for mountain work. This instrument had been compared with the Calcutta standard before the departure of the Mission, and was again verified on their return, and found to be unchanged.

[1] Dr. Scully describes it as follows: "The roof consisted of four folds of thick felt, on which dried grass or straw could be spread to any desired thickness, resting on a central tripod, and supported at the four corners by upright rods. The thermometers were suspended on a board attached to the tripod, 4 feet above the ground, so that the instruments were protected from the direct rays of the sun, and they were freely exposed to the air on all sides.

The regular hours of observation were 4 and 10 A.M., noon, and 4 and 10 P.M.; but it frequently happened that the day's march was not completed by 10 A. M., and that the observations of that hour were either lost or recorded in part at some intermediate station on the march. This latter practice was always observed on the high passes, at which generally a halt of one or two hours was made, and more than one set of readings recorded.

The readings of the minimum thermometers for shade and radiation temperatures were apparently recorded some time between 4 h. and 10 h., probably about daybreak, when the camp was breaking up and on the point of starting for the day's march. In most cases, the temperatures have been recorded to the nearest integral degree, and the decimals appear owing to the correction being added to the reading.

Solar radiation.—Taking the difference of the readings of the sun thermometer and of the maximum shaded thermometer as the measure of the solar intensity, the most intense radiation shewn in the register is that recorded in the Kárákásh and Núbra valleys (at Karghan Ali Nazar, Gulgan Shah Mazar, and Panamik) at elevations of 10,590, 12,250, and 10,550 feet respectively; and, next only to these, come the observations on the Kárákoram plateau, at elevations between 16,000 and 17,000 feet. At the former stations, differences of 70·3° to 75·6° were recorded; at the latter, the highest was 64·3°, *viz.*, on the 3rd September at Daulat Beg Uldi. This result seems paradoxical, since the solar radiation has to traverse an additional depth of from 4,000 to 6,000 feet of atmosphere to reach a thermometer in the Kárákásh or Núbra valleys, and the absorption of this stratum must be not inconsiderable. It may, indeed, be fortuitous, and owing to the fact that the diathermancy of the atmosphere was actually less during the passage of the Kárákoram plateau than when the travellers were threading the valleys to the north and south; but it is more probably attributable to the radiation received from the rocky sides of the valleys; in other words, to the more enclosed position of the thermometer on the valley bottom, as contrasted with that on the high level plains. It is much to be desired that, when an opportunity may present itself, observations of Hodgkinson's or some equally portable actinometer may be secured on these high plains.

A greater excess of radiative equilibrium temperature than the highest of the above has been recorded at the hill station of Murree and at stations on the plains of India.

Nocturnal radiation.—The greatest depression of the nocturnal radiation thermometer (below the air temperature) recorded in the register, is that on the 1st October at Matain, north of the Zoji Pass, at an elevation of 10,550 feet. This amounted to 12·4°. Other cases of a depression of 10° and upwards occurred at Murree (11·4°), Nurla (11·7°), and Panamik (10°). In general, the depression was small. The average of the nine nights passed at elevations of about 15,000 feet and upwards, was 4° only. That of eleven nights in the Kárákásh valley, at elevations of 10,600 feet to 13,200 feet, was 3·5°, and that of fifteen nights in the Núbra, Shayok, and Indus valleys, between 8,900 feet and 11,500 feet, was 4·6°. As far, therefore, as the observations shew, the depression of the exposed thermometer, in consequence of nocturnal radiation, seems to have varied but little with elevation.

Air temperature.—The changes of temperature recorded by Dr. Scully are affected by three circumstances, irrespectively of changes of wind and weather. In the first place, as the journey occupied nearly three months of the late summer and early autumn, a considerable fall between the earlier and later registers is due to change of season. In the second place, the route of the travellers being from north to south mainly, and from

the northern slopes of the great mountain mass to those which face southwards, they were passing from a normally cooler to a warmer climate; and lastly, the great changes of elevation, which marked the successive stages of the journey, were necessarily characterised by corresponding changes in the temperature of the atmosphere.

It is with the last class of variations that we are here most concerned. The characteristics of the Yárkand climate have already been discussed in a previous part of this volume; and these may be compared with the registers of Leh in the Indus valley, and with those of the Punjab and of stations on the southern slopes of the Himálaya, as given in the Annual Reports of the Indian Meteorological Department. Leaving these subjects aside, it remains to enquire into the effects of the varying elevation, freed as much as possible from the influence of other causes; and this may be done with comparative ease, by taking as data the mean of all the changes experienced during the ascents and descents; the variations arising from change of season and change of latitude being progressive and continuous. We may furthermore compare, as a whole, the temperature changes experienced in the general ascent to the Kárákoram plateau, with those of the descent; with due consideration of the general fall of temperature attributable to the season, as indicated by the registers of Yárkand and Leh respectively: and it will also be desirable to add a few words on the temperature characteristics of certain geographical sections of the route, *viz.*, the Kárákásh valley, the Kárákoram and Dipsang plains, and the Shayok and Núbra valleys.

In the following table are compared the mean temperatures of each halting-place; in most cases as obtained from the mean of the maximum and minimum thermometers, and the four or six observations of shade temperature at specified hours. Casual readings on passes, and those of camping stations at which the full daily series is imperfect, are compared with those of corresponding hours at the nearest camps on each side. Since, however, the day observations thus compared are much more numerous than the night observations, and it is at least probable that the decrement of temperature with elevation is by no means the same by day and night, it is necessary to distinguish the two; and the table gives, therefore, a comparison, in separate columns, of the means of the day observations (8, 10, 12, and 16 hours with maximum), and those of the night readings (22 and 4 hours, and the minimum). I include those cases only in which the difference of elevation during the day's march exceeded one thousand feet.

Changes of temperature with ascents and descents.

Stages.	Days interval.	Ascents or descents.	Difference of elevation.	Day Temperature.			Night Temperature.		
				Lower.	Upper.	Difference.	Lower.	Upper.	Difference.
Kizil Aghil to K. B. Mazar	1	A.	1330	58·5	61·4	+2·9	48·4	49·6	+1·2
Sanju to Chuchu Pass	2	A.	5120	61·1	39·0	−22·1	...	...	...
Chuchu Pass to Tadlik	1	D.	1950	51·6	39·0	−15·6	...	...	...
Chong Tash to Tadlik	1	A.	1020	55·7	54·2	−1·5	48·6	46·1	−2·5
Tadlik to Kichik Yailak	1	A.	2237	52·9	39·4	−13·5	47·1	34·1	−13·0
Kichik Yailak to Sanju Pass	1	A.	4633	38·8	30·0	−8·8	...	...	...
Sanju Pass to Oibuk	3	D.	4850	60·1	30·0	−30·1	...	...	...

Changes of temperature with ascents and descents,—continued.

Stages.	Days interval.	Ascents or descents.	Difference of elevation.	Day Temperature.			Night Temperature.		
				Lower.	Upper.	Difference.	Lower.	Upper.	Difference.
Barchal to K. Ali Nazar	1	D.	2070	58·7	41·6	−17·1	47·4	35·7	−11·7
Portash to Portash Pass	1	A.	3650	63·8	45·6	−18·2	...	...	...
Portash to Akin	1	A.	3170	...	...	...	43·7	28·3	−15·4
D. Sarighot to Brangsa	1	A.	1020	47·4	43·4	− 4·0	26·8	22·3	−4·5
Brangsa to Kárákoram Pass	1	A.	1410	44·1	33·5	−10·6	...	...	...
Kárákoram Pass to Murghu	2	D.	3390	55·1	33·5	−21·6	...	...	...
Dipsang Pass to Murghu	1	D.	2940	52·1	24·9	−27·2	...	...	...
Sasser to Sasser Pass	1	A.	2420	51·1	31·0	−20·1	...	...	...
Sasser Pass to Panamik	2	D.	7030	74·1	31·0	−43·1	...	...	...
Karawal Pass to Panamik	1	D.	4620	77·2	52·9	−24·3	...	...	...
Tsatti to below Khardong	1	A.	4910	59·2	49·2	−10·0	48·1	30·5	−17·6
Below Khardong to Khardong Pass ...	1	A.	2270	49·1	34·0	−15·1	...	...	...
Khardong Pass to Leh	1	D.	6287	61·1	30·5	−30·6	...	...	...
Below Khardong to Leh	1½	D.	4017	67·5	49·2	−18·3	44·2	30·5	−13·7
Leh to Nimu	1	D.	1027	...	...	...	47·8	47·7	−0·1
Saspol to Nurla	1	D.	1330	82·7	79·9	−2·8	61·5	56·1	−5·4
Nurla to Lama Yuru	1	A.	2390	77·5	59·0	−18·5	61·5	46·9	−14·6
Lama Yuru to Foto Pass	1	A.	2010	61·1	53·1	−8·0	...	...	...
Lama Yuru to Namika Pass	2	A.	1220	61·1	51·0	−10·1	...	...	...
Shergol to Karghil	1	D.	1660	66·2	43·9	−22·3	49·1	42·3	−6·8
Zogi Pass to Shita Kari	1	D.	2890	43·1	47·1	+1·0	...	...	...
Shita Kari to Kolan	1	D.	1260	48·2	48·2	0	40·4	38·9	−1·5
Kolan to Kanggan	1	D.	1380	57·5	48·2	−9·3	46·6	40·4	−6·2

Taking, separately, the observations between Yárkand and the Kárákoram, and those from the Kárákoram to Srinagar, the means of the day and night comparisons show the following increments of elevation for 1° Fahr. of temperature:—

	Day.	Night.	Mean.
Yárkand to Kárákoram	212 ft.	236 ft.	224 ft.
Kárákoram to Srinagar	188 „	273 „	230 „
Mean	200 „	254 „	227 „

The means of the 24 hours agree therefore fairly well; but it would seem that, while on the northern side of the plateau the decrement of day temperature with elevation is less rapid than on the southern side, that of the night is more so. In both cases, as was anticipated, the decrement is more rapid by day than by night, and the mean decrement of the 24 hours is 1° Fahr. for 227 feet, or 1° cent. for 133 metres, or 0·74° cent. for 100 metres. This last result may be considered the most trustworthy.

It shows that a more rapid decrement of temperature characterises the valleys and mountains of Tibet, than obtains on the plains of the Punjab and outer slopes of the

Himálaya. In the latter region, the mean decrement between Murree and Rawulpindi, in the months of August, September, and October, is 1° Fahr. in 407 feet, a rate which is little more than half of the above; and that between Chakráta and Roorkee is 1° in 326, or about two-thirds only.

The nearest approach to the rate of decrease in Tibet, hitherto observed in any other part of the Indian region, at this season, is that between Nuwera Eliya, in the central hills of Ceylon, and Batticaloa, on the east coast. This amounts to 1° for 226 feet in July, 242 feet in August, 252 feet in September, and 261 feet in October. There is, however, little analogy in the geographical characters of the two regions.

Accepting, provisionally, for the month of September, the mean decrement of 1° for 227 feet, which results from the foregoing data, we may compute therewith the mean temperature of the Kárákoram plateau, in the same month, at an average elevation of 16,000 feet, by comparison with Leh. The mean temperature of Leh in September, derived from the average of five years' observations, is 50·4°; the altitude being 11,500 feet or 4,500 feet below the plateau. Deducting 20° for the difference of elevation, this gives 30·4° for the mean temperature of the plateau in the same month. For Yárkand, in September we have no observations, but by a comparison with the course of the temperature variations of Tashkend and some other Russian stations, Dr. Hann has obtained for Yárkand an interpolated value for Dr. Scully's and some earlier observations of 19·2° Cent. =66·6 Fahr. The difference of elevations between Yárkand and the Kárákoram plateau being 12,000 feet, the mean September temperature of the latter computed from this datum at the adopted rate of decrement would be 13·8° Fahr. If, however, we give twice the weight to the value derived from Leh, on account of the greater proximity of that station, and the smaller difference of latitude, we obtain as the most probable value 26·1° F. as the mean temperature of the plateau at 16,000 feet in September.

The mean of the observed maximum and minimum temperatures on the six days, 1st to 6th September, at the camps between Durwaza Sarighot, and Sasser (mean elevation, 15,772 feet) is 35·1°; so that, considering that, at this season of year, the temperature is falling rapidly, the mean of the month at 16,000 feet, as above determined, is by no means improbable.

The mean temperature of the Kárákásh valley, between the 20th and 30th August, at elevations varying from 10,590 to 13,210 feet (mean 11,068 feet), is shown by the observations to be 53·2.° That of the Núbra valley, between the 9th and 12th September, at elevations of from 10,230 feet to 10,840 feet (mean 10,558 feet), is in like manner 43·4.°

The diurnal range of temperature, on the Kárákoram plateau, averaged not less than 35·1°, with fine clear weather. In the Kárákásh valley, where the weather was more cloudy, it averaged only 23·4°, on one day only rising to 34·9°, and in the Núbra valley, where also cloudy weather prevailed, 9·6°. At Leh the average range in September is 31·4°. In the year 1875 it was as much as 35·3°. From this it would appear that on the high plateau the range of daily temperature is at least as great as in the valleys on its borders.

Hourly observations of temperature were recorded at Karghalik and Sanju, in the Yárkand plain; at Kichik Yailak, on a rolling Alpine pasture below the Sanju pass, 11,850 feet above the sea; at Gulgan Shah Mazar, in the Kárákásh valley, at 12,250

[1] The mean temperature of November at Leh is 20° below that of September.

feet; at Leh, in the Indus valley; Srinagar, in Kashmir; and finally at Murree, the hill sanitarium of the Punjab. These, duly corrected for the errors of the instrument, are reproduced in the following table:—

Hourly Observations of Temperature in Yarkand, Tibet, and Kashmir.

Hours.	Karghalik, 4,429 feet, 4th August.	Sanju, 6,470 feet, 12th August.	Kichik Yailak, 11,650 feet, 19th August.	Gulgan S. Mazar, 12,250 feet, 23th August.	Leh, 11,503 feet, 19th September.	Srinagar, 6th October.	Murree, 21st October.
Midnight ...	64·6	62·1	35·2	40·5	54·0	43·1	52·1
1 ...	64·1	62·1	34·0	40·0	53·0	42·6	51·1
2 ...	63·6	61·1	33·5	40 0	50·5	40·2	49·6
3 ...	62·6	61·1	34·0	39·5	50·0	39 0	47 6
4 ...	60·2	65·3	34·9	39·0	49 0	40·0	47·1
5 ...	60·1	63·9	35·0	39·5	47·0	41·0	46·5
6 ...	61·1	63·1	36·0	40·0	44·0	41·0	46·1
7 ...	67·3	64·1	36·5	41·0	52·0	43·1	50·1
8 ...	72·1	68·1	36·0	43·6	58·0	47·6	52·1
9 ...	76·7	71·6	37·5	46·6	60·0	51·1	57·1
10 ...	81·2	76·2	38·8	52·1	62·5	54·6	58·1
11 ...	85·2	77·2	40·0	55·1	64·0	55·1	59·6
Noon ...	87·7	74·1	42·1	59·1	68·0	56·1	59·6
13 ...	88·5	75·4	40·5	59·1	68·5	60·1	59·1
14 ...	90·7	79·2	39·0	55·1	71·5	58·1	59·1
15 ...	89·7	75·2	39·0	55·1	68·0	58·1	58·1
16 ...	87·2	72·6	37·5	53·1	65·0	56·1	57·6
17 ...	84·2	70·1	37·0	50·1	63·5	55·1	54·1
18 ...	80·7	66·6	36·5	49·6	61·0	49·1	53·1
19 ...	77·7	66·6	36·0	49·6	60·0	48·1	52·6
20 ...	76·7	65·1	35·5	49·6	56·5	45 6	50·1
21 ...	75·2	62·6	35·0	49·1	54·0	44·1	49·1
22 ...	73·1	62 0	35·0	45·1	53·0	43·1	49·1
23 ...	72·1	58·1	35·0	45·0	53·0	41·0	49·1
Midnight ...	71·9	58·1	34·8	43·1	51·0	40·0	48·1

Air pressure.—The registers of pressure recorded during a journey such as Dr. Scully's, are chiefly of interest as affording data for determining the elevations, and also for affording some indication of the character and magnitude of the diurnal range in different situations on the mountains. Frequent changes of station prevent their throwing much light on the character of oscillations, whether periodical or otherwise, that are not completed within the occupation of one and the same camping-place.

The character of the annual oscillation of pressure, at an elevation of 11,500 feet in Tibet, is now known, from the observations of the Leh Observatory, to be very different in character from that which characterises the plains of India; proving, if even other evidence of the fact were wanting, that this region is beyond the sphere of the regular semi-annual change of the monsoons. At page 62 of this volume, a table was given, showing the mean pressure of each month at Leh, derived from the registers of two years and four months. The following table gives the average of from four to six years, (the three months, May to July, being represented by the means of four years only, and the four months, September to December, by those of six years,) and only slightly modifies the conclusions drawn from the former table:—

Mean monthly pressure at Leh.

	ins.		ins.
January ...	19·604	July ...	19·616
February ...	·578	August ...	·640
March ...	·640	September ...	·692
April ...	·649	October ...	·722
May ...	·668	November ...	·742
June ...	·650	December ...	·701

It shows that the absolute minimum pressure of the year falls in February; that a rise

of nearly 0·09 in the three following months, brings it to a first maximum in May; that it then falls 0·052 to a subordinate minimum in July; and then again rises nearly 0·13 to the absolute maximum of the year in November. The fall between December and January is very rapid; and this coincides with the setting in of the winter rains in Upper India. On a comparison of this variation with that which characterises the Himálayan Hill Stations at 7,000 feet, and again with that of the plains of Upper India, it seems probable that, at still greater elevations than Leh, for example on the Kárákoram plateau, the early spring minimum would be found relatively lower, and the July minimum still less marked; while the absolute maximum would probably fall somewhat earlier, possibly in October: and by ascending still higher, we might at length attain a level, at which the annual oscillation of the Indian plains would be found reversed. The three curves of the annual variation at Lahore, Chuckrata, and Leh are shewn in Fig. 2 plate XV.

The hourly observations of pressure recorded by Dr. Scully during prolonged halts, and those which he has furnished, as far as possible, from all camps, for the approximately critical hours of 4, 10, 16 and 22, are of extreme value for the information they afford respecting the diurnal oscillations of pressure at great altitudes. The following table gives the results of the hourly observations recorded at the same seven stations as furnished the temperature observations already detailed on the previous page.

Hourly Observations of the Barometer reduced to 32° Fahrenheit, and corrected to the Calcutta standard.

Hours.	Karghalik, 4,420 feet, 4th August.	Sanju, 6,470 feet, 12th August.	Kichik Yailak, 11,850 feet, 10th August.	Gulgan Shah M, 12,250 feet, 28th August.	Leh, 11,503 feet 19th September.	Srinagar, 5,250 feet, 6th October.	Murree, 7,410 feet 21st October.	Hours.
Midnight ...	25·362	23·639	19·415	19 166	19·731	24·878	23·012	Midnight.
1 ...	·378	·641	·419	·175	·727	·880	·020	1
2 ...	·377	·655	·425	·173	·727	·876	·024	2
3 ...	·383	·665	·421	·171	·725	·873	·022	3
4 ...	·387	·691	·393	·171	·727	·883	·018	4
5 ...	·387	·717	·391	·168	·729	·891	·032	5
6 ...	·399	·725	·392	·165	·752	·895	·036	6
7 ...	·423	·721	·394	·165	·762	·905	·016	7
8 ...	·431	·724	·402	·165	·806	·909	·060	8
9 ...	·439	·728	·421	·170	·807	·932	·073	9
10 ...	·430	·729	·425	·159	·801	·936	·093	10
11 ...	·415	·720	·421	·143	·793	·927	·091	11
Noon ...	·401	·708	·417	·126	·754	·905	·089	Noon.
13 ...	·385	·704	·417	·120	·734	·885	·079	13
14 ...	·360	·692	·417	·106	·710	·877	·075	14
15 ...	·328	·685	·415	·112	·678	·887	·067	15
16 ...	·320	·683	·423	·131	·676	·883	·063	16
17 ...	·317	·680	·435	·140	·676	·889	·059	17
18 ...	·321	·680	·441	·142	·660	·897	·065	18
19 ...	·329	·687	·449	·142	·681	·899	·066	19
20 ...	·359	·703	·477	·154	·705	·912	·066	20
21 ...	·389	·711	·483	·172	·715	·914	·070	21
22 ...	·402	·715	·488	·213	·723	·920	·072	22
23 ...	·428	·703	·486	·226	·725	·927	·058	23
Midnight ...	·428	·701	·475	·222	·745	·930	·026	Midnight.

Correcting these by distributing equally the difference of the initial and terminal midnight observations, the hourly variations of these series are as follow :—

Variation of the hourly barometric readings from the diurnal means, derived from the preceding table.

Hours.	Karghalik.	Sanju.	Kichik Yailak.	Gulgan Shah Mazar.	Leh.	Srinagar.	Murree.	Hours.
Midnight	+·012	—·027	+·016	+·046	+·007	+·003	—·038	Midnight.
1	+·026	—·027	+·018	+·033	+·003	+·003	—·030	1
2	+·022	—·016	+·021	+·030	+·002	—·003	—·027	2
3	+·025	—·008	+·015	+·026	—·001	—·008	—·029	3
4	+·026	+·015	—·016	+·025	+·001	0	—·034	4
5	+·024	+·038	—·020	+·020	+·002	+·006	—·020	5
6	+·033	+·040	—·022	+·018	+·025	+·007	—·017	6
7	+·054	+·039	—·022	+·004	+·034	+·015	—·008	7
8	+·059	+·038	—·017	+·013	+·078	+·017	+·006	8
9	+·065	+·039	0	+·016	+·078	+·038	+·018	9
10	+·053	+·037	+·001	+·004	+·071	+·040	+·038	10
11	+·035	+·028	—·005	—·014	+·063	+·029	+·035	11
Noon	+·018	+·011	—·012	—·032	+·023	+·004	+·033	Noon.
13	0	+·005	—·014	—·040	+·003	—·018	+·022	13
14	—·028	—·010	—·017	—·055	—·022	—·028	+·017	14
15	—·063	—·020	—·021	—·051	—·055	—·020	+·009	15
16	—·074	—·024	—·016	—·033	—·057	—·026	+·004	16
17	—·079	—·030	—·006	—·026	—·058	—·022	0	17
18	—·078	—·032	—·003	—·025	—·074	—·017	+·005	18
19	—·073	—·028	+·003	—·027	—·057	—·017	+·005	19
20	—·046	—·015	+·028	—·016	—·031	—·006	+·005	20
21	—·018	—·009	+·032	0	—·021	—·006	+·008	21
22	—·008	—·008	+·034	+·040	—·014	—·002	+·010	22
23	+·015	—·022	+·030	+·051	—·012	+·003	—·005	23
Mean	25·383	23·697	19·429	19·158	19·731	24·901	23·057	

Of the above stations, Karghalik is in the plains of Yárkand, at no great distance from the city of that name, and, as might be anticipated, the general character of the variation is similar to that which has been deduced for Yárkand from the more numerous observations discussed in a former part of this volume. Sanju, also on the plains, is at a greater elevation and close to the foot of the mountains. Kichik Yailak is on an open alpine slope, on the north side of the Sanju Pass, and overlooking the plains. The day of the observations at this station was throughout overcast, with a constant drizzle; and hence probably, in part, the smallness of the barometric range; but it is also probable that the shallowness of the afternoon depression is due in part to the situation, and is an approximation to the condition characteristic of mountain peaks.

Gulgan Shah Mazar is in the Kárákash valley, with the lofty Kuen Lun to the north

and the Kárákoram plateau, 4,000 or 5,000 feet above the valley, on the south. Leh is in the Indus valley, bounded on both sides by lofty ranges; Srinagar in the mountain-girt plains of Kashmir; and Murree on a ridge of the chain that divides Kashmir, or rather the valley of the Jhilum, from the Potwar or high level plain of the Punjab. The curves of the preceding table are represented graphically on plate XV.

A single day's observation furnishes, however, but a very uncertain criterion of the character of the diurnal variation; and some additional value may be given to the result, by taking into consideration the variation on other days, on which observations have been recorded at least at the four six-hourly intervals. Of the stations enumerated, Karghalik furnishes three complete days; Sanju, four days; Gulgan Shah Mazar, four days; Leh, nearly seven days; and Srinagar three and a half days. For Kichik Yailak we have one and half only, and for Murree one and three-fourths days.

From these data, the following variations from the mean of the day have been deduced, for the hours of observation[1]:—

	Days.	4 Hours.	10 Hours.	16 Hours.	22 Hours.
		Inches.	Inches.	Inches.	Inches.
Karghalik	3	+·005	+·033	—·055	+·016
Sanju	4	+·002	+·014	—·025	+·008
Kichik Yailak	$1\frac{1}{2}$	—·013	—·002	—·016	+·030
Gulgan Shah Mazar	4	+·029	+·017	—·066	+·022
Leh	7	—·001	+·070	—·048	—·023
Srinagar	$3\frac{1}{2}$	—·004	+·049	—·031	—·014
Murree	$1\frac{3}{4}$	—·003	—·004	—·007	+·014

With the exception of Murree, the values thus obtained, are as consistent with curves of the general character of those afforded by the hourly observations as can be expected. The results obtained for Gulgun Shah Mazar and Leh[2] more especially are

[1] These have been computed in the following manner, on the assumption that the mean of the four six-hourly observations is the mean pressure of the day. Let a, b, c, d; a^1, b^1, c^1, d^1, &c. represent the observations of consecutive days. Then the variation of each hour (excepting the first two and last two) is assumed to be obtained by the following formula:—

$$c - \frac{\frac{1}{2}a + b + c + d + \frac{1}{2}a^1}{4} \qquad d - \frac{\frac{1}{2}b + c + d + a^1 + \frac{1}{2}b^1}{4} \text{ \&c.}$$

The two initial and two final observations are compared with the means of the first and last days respectively, with a proportional correction for the rise or fall during the day. Thus for a and b the variations are—

$$a - \frac{a + b + c + d}{4} + \frac{a - a^1}{2} \qquad b - \frac{a + b + c + d}{8} + \frac{a - a^1}{4}$$

The means of all the values of homonymous hours thus separately obtained, are then corrected to a general mean.

[2] The following data for the Leh curve in September are deduced from 12 complete series of hourly observations recorded on the 7th, 14th, 21st and 28th of the month in 1876, 1877, and 1878.

Hourly variation of Pressure at Leh in September.

Hours.	Inches.	Hours.	Inch.	Hours.	Inch.
Midnight ...	+·001	8 ...	+·054	16 .	−·062
1 ...	+·006	9	+·058	17	−·063
2 ...	+·010	10 ...	+·018	18 .	−·056
3 ...	+·015	11 ..	+·027	19 ..	−·037
4 ...	+·020	Noon .	+·004	20 ..	−·024
5 ..	+·028	13 ...	−·017	21 .	−·015
6 ...	+·037	14 ...	−·037	22 ...	−·008
7 ...	+·018	15 ...	−·054	23 ...	−·005

very consistent, and show a remarkable regularity in the diurnal variation, on consecutive days. The curves of Karghalik, Leh, and Srinagar bear a considerable resemblance to each other, and also to the curves of Yárkand in the summer months (Plate VIII). But that of Gulgan Shah Mazar, the situation of which is not very dissimilar from that of Leh, is of a very different character, the night maximum being apparently greatly in excess of that of the morning. With a view to the further illustration of this interesting subject, I give, in the following table, the rise and fall between each pair of consecutive observations at the six hourly intervals; and take the mean of all the stations, under similar geographical conditions, for the three sections of the journey, *viz.*, the Kárákásh valley between 10,590 feet and 13,210 feet; the Kárákoram plateau and Upper Shayok, between 14,840 feet and 16,800 feet; and the Núbra valley between 10,230 feet and 10,840 feet.

Kárákásh Valley.

Camps	Elevation	4 to 10	10 to 16	16 to 22	22 to 4
Baz Chat	12,660		.	+·067	−·010
Karghan Ali Nazar	10,590		.	+·102	−·081
Toghrasu ..	11,150	.		+·081	−·023
Oibuk	11,630	.	−·110	+·071	−·013
"	...	−·024	−·078	+·073	+·005
Balakchi	11,880		−·119	+·121	+·008
Gulgan Shah Mazar	12,250	.	−·056	+·147	+·017
" "	.	+·009	−·091	+·121	−·005
" "	.	−·012	−·028	+·082	+·028
" "	.	−·005	−·112	+·055	+·024
Portash .	13,210		−·025	+·139	−·046
Means	...	−·008	−·077	+·096	−·009
Kárákoram Plateau, &c.					
Balak Bachi .	16,380	.	.	..	−·013
Durwaza Sarighot	15,800	...	..	+·014	−·006
Brangsa ..	16,800	...	+·004	+·036	−·009
Daulat Beg Uldi .	16,460	..	..	...	+·016
Burtse ...	15,550				+·020
Murghu ...	14,840		−·052	+·004	−·010
Sasser	15,160		−·082	+·036	+·015
Toti Yailak .	15,370	..	..		−·018
Means ..	...	.	−·043	+·030	−·001
Núbra Valley.					
Chang Lung .	10,840	.		−·006	+·016
Panamik	10,550	..	−·103	+·143	+·016
Taghar ...	10,230		+·002	+·058	−·003
Tsatti	10,610	..	...	+·060	+·015
Means ..	...	..	−·050	+·064	+·011

As far as these data go, they seem to show that the character of the oscillation is very similar in the Kárákásh and Núbra valleys, and consists essentially of a great mid-day fall of pressure and a great rise in the evening, such as was illustrated in the curve of the hourly observations at Gulgan Shah Mazar. Both the foregoing table, and those of the hourly and six-hourly observations at Gulgan Shah Mazar, previously given, indicate that, unlike Leh, Srinagar, and places on the plains generally, the absolute maximum of the day occurs near midnight or in the early morning hours, a most unusual feature of the diurnal variation; but further evidence would be necessary to establish this as a fact, and meantime it must be regarded as more or less open to question.

The stations above 15,000 feet show a variation of the normal character, but apparently of smaller range. The data, however, are too fragmentary to admit of any trustworthy conclusions.

The single day's observations at Murree yield a curve, which shows, in an exaggerated degree, the peculiar features characteristic of mountain peaks, *viz.*, an absolute minimum in the night or early morning [?], and an absolute maximum in the forenoon; and, as far as can be judged from the subsequent regular registers of the station, for three entire years, at 10 h. and 16 h., the average fall of pressure between those hours does not exceed that exhibited in the curve. It is desirable that the character of the night oscillation should be further investigated.

Winds.—Dr. Henderson's remark that, in Tibet and Yárkand, the winds blow up the valleys in the day-time and down them at night, has been quoted in a previous part of this volume.[1] This is a well-known phenomenon in mountainous countries; and its physical explanation, which, until lately, has been given only in a partial and imperfect form by most writers on the subject, has been recently set forth in a very lucid and admirable paper, by Dr. J. Hann, published in the *Sitzungsberichte* of the Vienna Academy.

According to Dr. Scully's register, the winds were chiefly westerly on the Yárkand plains,[2] and northerly in the Sanju and Kárákásh valleys, occasionally interrupted by calms, especially during the halt at Gulgan Shah Mazar. The northerly or north-east (up-valley) wind continued to the Portash Pass, where the travellers were met by a south-west wind registered at force 4. From this to the Dipsang, strong winds blew from west or south in the day-time, falling to calm at night. This is a well-known characteristic of the high plains of Tibet, and has been often described by travellers. After passing the Karawal Diwan into the Núbra valley, the up-valley winds were chiefly from south, and on two days it was calm. Across the Khardong Pass, the wind blew from north, and at Leh and in the Indus valley, the winds were very light or calm. In the Kashmir valley, calms also prevailed.

Hygrometry and Cloud.—The hygrometric values have been computed directly from the observations, by August's formula. They are of very great interest, more especially for the information they afford respecting the vertical decrement of vapour distribution, in the generally dry climate of the Tibetan highlands. In order to ascertain this approximately, I have grouped the observations according to the elevations of the stations. The result can be regarded only as an approximation to the mean vertical distribution, since, not only are the variations due to geographical position and the

[1] Page 56.

[2] In a few instances in the register the wind entry is "calm," but of estimated force 1. I leave the entry as I find it. The probable meaning is that light zephyrs alternated with intervals of calm.

change of season very considerable, and the irregular or non-periodic fluctuations also great, but the diurnal periodic variation is too variable to admit of any valid correction being applied to observations taken at different hours of the day; and I am obliged, therefore, for the purpose of comparison, to take the simple means of all observations recorded within the same limits of elevation. These data are given in the following tables; the first of which sums up the observations between certain limits of elevation, separately, for each section of the journey; the second takes account of the elevation alone:—

	Range of Elevation	Mean	No of observations	Mean tension
Yárkand Plains	4,000 to 5,000 feet	4,333 feet	36	0 429 inches
Ditto	5,000 „ 7,000 „	6,189 „	38	0 300 „
Sanju Valley	7,000 „ 10,000 „	8,697 „	17	0 287 „
Ditto	1,0000 „ 14,000 „	11,817 „	9	0 204 „
Sanju Pass		16,480 „	1	0 151 „
Kárákásh Valley	10,000 „ 14,000 „	12,017 „	54	0 186 „
Kárákoram Plateau	14,000 „ 18,200 „	16,030 „	33	0 106 „
Núbra Valley	10,000 „ 11,000 „	10,509 „	12	0 234 „
Khardong Camp and Pass	15,580 „ 17,800 „	16,277 „	6	0 131 „
Indus Valley	10,000 „ 14,000 „	11,237 „	64	0 168 „
Ditto	7,000 „ 10,000 „	8,967 „	9	0 199 „
Valley Sind ..	7,000 „ 10,000 „	8,216 „	11	0 254 „
Kashmir	5,000 „ 7,000 „	5,304 „	28	0 258 „
Ditto	4,000 „ 5,000 „	4,576 „	11	0 227 „
Ditto	2,000 „ 4,000 „	2,469 „	16	0 379 „

The summary of the above gives the following:—

Range of Elevation	Mean	No of Observations	Mean tension
Feet	Feet		Inch
14,000 to 18 200	16,078	40	0 111
10,000 to 14 000	11,230	139	0 192
7,000 to 10,000	8,620	37	0 256
5,000 to 7,000	5,813	66	0 282
4 000 to 5 000	4 390	47	0 382

The observations of relative humidity, treated in the same manner as the above, give the following mean results :—

	Range of Elevation.	Mean.	No. of Observations.	Rel. Hum.
	Feet.	Feet.		Per cent.
Yárkand Plains ...	4,000 to 5,000	4,333	36	46
Ditto ...	5,000 to 7,000	6,189	38	49
Sanju Valley ...	7,000 to 10,000	8,697	17	77
Ditto ...	10,000 to 14,000	11,817	9	92
Sanju Pass ...	...	16,450	1	91
Kárákásh Valley ...	10,000 to 14,000	12,017	54	50
Kárákoram Plateau ...	14,000 to 18,200	16,030	33	53
Núbra Valley ...	10,000 to 11,000	10,509	12	69
Khardong Camp and Pass	15,500 to 17,600	16,277	6	62
Indus Valley ...	10,000 to 14,000	11,237	64	48
Ditto ...	7,000 to 10,000	8,967	9	42
Sind Valley ...	7,000 to 10,000	8,218	11	58
Kashmir ...	5,000 to 7,000	5,304	28	74
Ditto ...	4,000 to 5,000	4,576	11	51
Ditto ...	2,000 to 4,000	2,469	16	66

and classified for elevation only, irrespective of time and geographical situation.

Range of Elevation.	Mean.	No. of Observations.	Rel. Hum.
Feet.	Feet.		Per cent.
14,000 to 18,200	16,078	40	56
10,000 to 14,000	11,230	139	53
7,000 to 10,000	8,620	37	72
5,000 to 7,000	5,813	66	60
4,000 to 5,000	4,390	47	47

From this it would appear that the Indus and Kárákásh valley systems, and the massive table land between them, enjoy a much drier climate than either Kashmir or Yárkand, from which they are separated by the Luduk and Kuen Lun ranges respectively. The Sind valley, leading up from Kashmir to the Zogi pass, and the Sanju valley, leading up to the pass of the same name, were both considerably more humid than the valleys at equal elevations leading down from those passes on the opposite slopes. This may, however, be fortuitous. The climate of Kashmir is also more humid than that of Yárkand.

The following are the results of the hourly observations of the psychrometer recorded at the several halting-places previously enumerated.

Hourly Observations of Vapour Tension in Yárkand, Tibet, and Kashmir.

Hours.	Karghalik, 4,429 feet, 4th August.	Sanju, 6,470 feet, 12th August.	Kichik Yailak, 11,850 feet, 19th August.	Gulgan S. Mazar, 12,250 feet, 28th August.	Leh, 11,503 feet, 19th September.	Srinagar, 6th October.	Murree, 21st October.
Midnight	0·408	0·298	0·194	0·191	0·192	0·256	0·144
1	·385	·285	·188	·230	·191	·258	·135
2	·350	·271	·185	·221	·204	·242	·122
3	·307	·247	·188	·217	·199	·218	·123
4	·297	·204	·188	·221	·188	·167	·137
5	·297	·183	·196	·221	·225	·175	·142
6	·337	·169	·196	·230	·232	·195	·186
7	·351	·216	·208	·226	·219	·235	·165
8	·366	·260	·204	·218	·249	·260	·228
9	·373	·199	·217	·219	·252	·289	·220
10	·384	·151	·222	·200	·252	·310	·232
11	·420	·153	·221	·223	·239	·280	·240
Noon	·442	·148	·231	·240	·249	·244	·263
13	·416	·184	·235	·219	·300	·271	·263
14	·460	·153	·230	·174	·207	·246	·256
15	·453	·186	·230	·213	·204	·246	·260
16	·414	·214	·213	·172	·198	·280	·260
17	·432	·226	·213	·208	·179	·274	·251
18	·439	·250	·208	·193	·191	·288	·196
19	·409	·250	·204	·175	·169	·266	·191
20	·389	·254	·200	·175	·190	·250	·206
21	·391	·280	·196	·170	·183	·245	·237
22	·399	·323	·196	·205	·231	·256	·237
23	·380	·365	·196	·205	·231	·237	·237
Midnight	·380	·352	·198	·222	·209	·227	·248

Hourly Observations of Humidity in Yárkand, Tibet, and Kashmir.

Hours.	Karghalik, 4,420 feet, 4th August.	Sanju, 6,470 feet, 12th August.	Kichik Yailak, 11,850 feet, 19th August.	Gulgan S. Mazar, 12,250 feet, 28th August.	Leh, 11,503 feet, 19th September.	Srinagar, 6th October.	Murree, 21st October.
Midnight	67	53	91	76	46	92	37
1	65	51	96	92	47	94	36
2	59	50	96	89	56	96	34
3	54	46	96	89	55	92	37
4	57	33	92	92	51	67	42
5	57	31	96	90	69	68	44
6	63	30	92	92	80	76	60
7	53	36	96	86	56	85	45
8	46	39	96	77	51	79	59
9	41	26	96	69	49	77	47
10	36	17	94	51	44	73	48
11	35	17	89	52	40	64	47
Noon	34	18	86	48	36	54	51
13	32	21	93	44	28	52	53
14	32	16	96	40	27	51	51
15	32	22	96	49	30	51	53
16	32	27	94	43	32	62	54
17	37	31	96	57	30	64	60
18	42	39	96	55	35	83	48
19	44	39	96	49	32	79	48
20	43	41	96	49	42	82	57
21	45	50	96	49	44	85	68
22	49	58	96	68	57	92	68
23	48	76	96	68	57	92	68
Midnight	49	73	98	80	56	92	74

RESULTS OF OBSERVATIONS RECORDED ON THE MARCH BETWEEN YÁRKAND IN KASHGHAR AND MURREE IN THE PUNJAB, BY DR. J. SCULLY AND ASSISTANTS.

N. B.—*The elevations in brackets are those determined by Captain Trotter, R. E.*

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected.)	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, deduct.	Maximum thermometer.	Minimum thermometer.	Barometer reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
July	29th	16	Yangaklik ...	4,140	...	...	...	...	...	...	25·480	99·8	72·2	·473	25	.	...	0	l.
„	„	22	„ ...	...	155·0	52·4	...	...	102·6	...	·528	67·9	66·2	·625	91	...	2	0	
	30th	4	„ ...	...	...	...	...	...	..	...	·567	66·1	59·1	·423	66	...	2	0	l.
							60·0	3·3	...	64·2									
„	„	10	Igarchi ...	4,090	...	...	...	...	...	...	·595	85·2	69·2	·529	44	...	2	0	l.
„	„	16	„ ...	...	...	...	...	...	..	..	·471	97·8	77·6	·713	38	W.	2	0	l.
„	„	22	„ ...	...	150·2	46·8	...	...	103·4	...	·480	75·2	70·2	·682	78	...	2	...	...
„	31st	4	„ ...	...	...	...	...	...	...	...	·576	65·1	62·2	·528	85	...	2	2	C. l.
							63·1	0·8	...	64·2									
„	„	10	Posgam ...	4,320 (4,210)	...	...	...	...	...	...	·343	82·2	67·7	·513	47	...	1	0	b.
„	„	12	„ ...	...	...	...	...	...	...	...	·276	87·2	69·2	·500	39	...	1	0	l.
„	„	16	„ ...	...	...	...	..	...	...	...	·233	82·2	71·2	·640	58	...	1	10	o.
„	„	22	„ ...	...	139·5	46·6	...	...	92·9	...	·286	78·2	61·1	·316	36	...	...	...	...
Aug.	1st	4	„ ...	...	...	...	...	...	...	...	·337	65·1	57·6	·393	63	Calm	1	0	l.
							57·9	6·3	...	64·2									
„	„	10	Yakshamba Bazar.	4,240	...	...	...	...	...	...	·383	79·2	63·4	·401	40	N.W.	4	10	o.
„	„	12	„ ...	...	...	...	...	...	...	...	·356	85·2	68·2	·497	41	N.W.	2	...	o.
„	„	16	„ ...	...	...	...	...	..	..	.	·333	85·2	70·2	·568	47	N.N.W.	1	10	o.
„	„	22	„ ...	...	135·0	35·8	...	...	93·2	...	·421	73·9	64·0	·481	58	Calm	1	10	...
„	2nd	4	„ ...	...	...	...	...	..	...	...	·419	66·1	59·1	·423	66	S.E.	1	10	o.
							59·9	5·3	..	65·2									
„	„	10	Karghalik ...	4,429 (4,410)	...	...	...	...	...	...	·313	88·2	61·6	·247	19	Calm	1	10	c.
„	„	12	„ ...	...	...	...	...	...	...	...	·259	89·7	62·2	·219	18	S.	1	...	c.
„	„	16	„ ...	...	...	...	...	...	...	...	·221	90·2	64·2	·307	22	Calm	1	0	b.
„	„	22	„ ...	...	...	...	..	...	..	...	·286	70·6	61·1	·432	58	E.	1	10	...
„	3rd	4	„ ...	...	...	...	..	...	.	...	·236	63·1	54·0	·317	55	S.	2	10	o.
							57·4	3·9	...	61·3									
„	„	10	„ ...	...	...	...	...	...	...	...	·265	79·2	62·7	·384	38	W.	1	10	o.
„	„	12	„ ...	...	...	...	...	...	...	...	·212	87·7	65·2	·367	28	W.	1	...	o.
„	„	16	„ ...	...	...	...	...	...	...	...	·233	88·2	66·2	·395	30	Calm	1	10	o.
„	„	22	„ ...	...	145·5	50·1	...	...	95·1	...	·353	70·1	60·1	·405	55	Calm	1	10	...
„	4th	4	„ ...	...	...	...	...	...	...	...	·387	69·2	52·0	·297	57	Calm	1	10	o.
							53·6	5·7	...	59·3									

Results of Observations recorded on the march between Yárkand in Kashghar and Murree in the Punjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
Aug.	4th	10	Karghalik ...	...	...	...	...	...	...	...	25·430	81·2	63·7	·391	37	E.N.E.	1	0	*b.*
„	„	16	„ ...	...	...	...	...	...	...	...	·320	87·2	66·7	·422	33	N.N.W.	2	10	*m.*
„	„	22	„ ...	...	141·0	48·6	...	...	92·4	...	·402	73·1	61·1	·403	49	Calm	1	10	...
„	5th	4	„ ...	...	...	...	...	...	...	...	·447	63·1	55·1	·345	60	Calm	1	10	*m.*
							59·4	3·3	...	62·7									
„	„	10	Basharik ...	4,480	...	...	...	...	...	...	·348	80 0	63·2	·389	38	N.W.	2	10	*m.*
„	„	12	„ ...	...	...	...	...	...	...	...	·393	84·2	64·2	·373	32	N.W.	1	...	*m.*
„	„	16	„ ...	...	...	...	...	...	...	..	·193	88·2	65·2	·361	27	E.	1	10	*m.*
„	„	22	„ ...	...	140·5	45·9	...	...	94·6	...	·254	68·1	57·6	·359	52	Calm	1	10	...
„	6th	4	„ ...	...	...	...	...	...	...	...	·242	66·1	53·0	·256	40	S.S.E.	2	10	*m.*
							60·4	2·8	...	63·2									
„	„	10	? ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	„	12	Bora ...	5,384 (5,340)	...	...	...	...	...	...	24·562	84·2	64·2	·371	32	Calm	0	0	*b.*
„	„	16	„ ...	...	...	...	...	...	...	...	·499	84·4	62·7	·332	28	E.	2	10	*m.*
„	„	22	„ ...	...	135·0	42·8	...	...	92·2	...	·566	70·1	58·1	·354	48	Calm	0	10	...
„	7th	4	„ ...	...	...	...	...	...	...	...	·569	65·1	55·1	·329	53	Calm	0	10	*m.*
							61·4	1·3	...	62·7									
„	„	10	Oi Toghrak ...	5,885 (5,760)	...	...	...	...	...	...	·184	82·7	60·1	·277	25	W.	4	0	*b.*
„	„	12	„ ...	...	...	...	...	...	...	...	·150	85·7	61·6	·288	23	N.N.W.	2	0	*b.*
„	„	16	„ ...	...	...	...	...	...	...	...	·066	86·6	62·2	·297	23	E.	1	10	*m.*
„	„	22	„ ...	...	137·5	45·3	...	...	92·2	...	·101	78·0	57·6	·262	27	W.	4	10	...
„	8th	4	„ ...	...	...	...	...	...	...	...	·243	64·1	53·5	·297	50	W.	4	10	*m.*
„	„	12	Koshtak ...	5,970	...	...	...	...	...	...	·093	71·1	58·1	·345	45	Calm	...	...	*cc.*
„	„	16	„ ...	...	...	...	...	...	...	...	·015	74·3	57·6	·297	35	N.W.	1	10	*cc.*
„	„	22	„ ...	...	113·5	34·9	...	...	78·6	...	·036	65·1	55·1	·331	53	Calm	0	10	*cc.*
„	9th	4	„ ...	...	...	...	...	...	...	...	23·966	61·6	57·1	·421	77	S.S.W.	1	10	*cc.*
„	„	10	Salik Aziz Langar.	6190	...	...	...	...	...	...	·970	61·1	54·0	·345	64	W.	3	10	*d. r. a few little r. drops*
„	„	12		...	...	...	...	...	...	...	·980	59·1	53·8	·360	72	N.W.	...	...	...
„	„	16	„ ...	...	...	...	...	...	...	...	·956	64·9	57·1	·384	62	N.W.	2	10	*cc.*
„	„	22	„ ...	...	93·5	25·3	...	...	68·2	...	·978	61·1	58·1	·453	84	Calm	1	10	*cc.*
„	10th	4	„ ...	...	...	...	...	...	...	...	·946	59·1	50·0	·264	52	Calm	0	10	*cc.*
							54·4	2·5	...	56·9									
„	„	10	Sanju ...	6,470 (6,070)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„	„	12	„ ...	...	...	...	...	...	...	...	·617	78·7	58·6	·281	29	Calm	...	0	*bb.*
„	„	16	„ ...	...	...	...	...	...	...	...	·574	79·2	58·1	·262	26	Calm	0	3	*Ks. bb.*

Results of observations recorded on the march between Yārkand in Kashghar and Murree in the Panjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, direct.	Nocturnal radiation.	Nocturnal radiation, deduct.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry bulb thermometer.	Wet bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather and clouds.
1875.																			
Aug.	10th	22	Sanju ...	6470	138·5	55·3	...	...	83·2	...	23·643	57·6	49·5	·270	57	Calm.	0	2	Ks.
,,	11th	4	,, ...	...	...	...	...	...	...	...	·670	57·6	50·0	·279	59	Calm.	0	10	cc.
							51·3	6·0	...	57·3									
,,	,,	10	,, ...	...	...	...	...	...	...	...	·683	77·2	59·1	·310	33	S.	2	9	Ks. cc.
,,	,,	12	,, ...	...	...	...	...	...	...	...	·617	81·2	61·1	·326	31	Calm.	...	9	Ks. c.
,,	,,	16	,, ...	...	...	...	...	...	...	...	·617	81·2	61·1	·326	31	Calm.	1	9	C. Ks. c.
,,	,,	22	,, ...	...	148·5	62·1	...	...	86·4	...	·647	62·3	53·5	·319	57	Calm.	0	10	cc.
,,	12th	4	,, ...	...	...	...	...	...	...	...	·690	65·3	50·0	·201	32	W.	3	10	c.
							56·4	4·9	...	61·3									
,,	,,	10	,, ...	...	...	...	...	...	...	...	·729	76·2	52·5	·146	16	W.	2	10	cc.
,,	,,	12	,, ...	...	...	..	...	...	...	...	·708	74·1	51·5	·144	17	W.	...	7	Ks. b.
,,	,,	16	,, ...	...	...	...	...	...	...	...	·683	72·6	53·5	·213	27	Calm.	0	10	cc.
,,	,,	22	,, ...	...	143·5	61·9	...	...	81·6	...	·715	62·0	53·5	·322	58	Calm.	0	10	cc.
,,	13th	4	,, ...	...	...	...	...	...	...	...	·701	56·6	50·0	·292	63	W.	1	10	cc.
							52·5	3·2	...	55·7									
,,	,,	10	,, ...	...	...	...	...	..	...	...	·803	58·1	54·0	·375	77	W.	2	10	cc. r. 9-22 h.
,,	,,	12	,, ...	...	...	...	...	...	...	...	·798	58·1	53·0	·350	72	W.S.W.	...	...	dr.
,,	,,	16	,, ...	...	...	...	...	...	...	...	·817	54·1	52·0	·367	87	Calm.	0	10	dr.
,,	,,	22	,, ...	...	110·0	47·7	...	...	62·3	...	·857	51·1	50·0	·350	93	Calm.	0	10	dr.
,,	14th	4	,, ...	...	...	...	...	...	...	...	·839	52·1	51·0	·364	93	Calm.	0	10	dr.
							51·0	0·5	...	51·5									
,,	,,	10	,, ...	...	...	...	...	...	...	...	·755	61·1	53·0	·317	59	W.	3	10	cc.
,,	,,	16	Kizil Aghil ...	7070	...	...	...	...	...	...	·157	55·1	50·0	·310	71	Calm.	0	10	cc.
,,	,,	22	,, ...	...	92·0	30·1	...	...	61·9	...	·183	52·1	49·9	·338	87	Calm.	0	10	cc.
,,	15th	4	,, ...	...	...	...	...	...	...	...	·194	46·6	45·5	·294	92	Calm.	0	4	Cs. b.
							42·8	3·7	...	46·5									
,,	,,	10	,, ? ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,,	,,	12	Khuda Berdi Mazar.	8400	...	...	...	...	...	...	22·094	58·1	49·5	·271	56	E.	...	...	cc.
,,	,,	16	,, ...	...	...	...	...	...	...	...	·092	56·1	48·5	·268	59	W.	2	10	cc.
,,	,,	22	,, ...	...	87·0	20·2	...	...	66·8	...	·110	51·1	48·0	·305	81	Calm.	0	10	cc.
,,	16th	4	,, ...	...	...	...	...	...	...	...	·080	49·1	46·0	·282	81	...	...	...	...
							45·9	2·7	...	48·6									
,,	,,	8	Chuchu Pass ...	11590	...	...	...	...	...	...	19·566	...	...	...	...	...	...	...	...
,,	,,	10	,, ...	...	...	...	...	...	...	...	·562	39·0	...	...	...	...	...	...	...
,,	,,	16	Chong Tash ...	8590	...	...	...	...	...	...	22·008	51·1	47·5	·294	78	N. W.	3	10	dr.

Results of observations recorded on the march between Yárkand in Kashghar and Murree in the Panjab, by Dr. J. Scully and Assistants—continued.

Month.	Days.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind.		Cloud proportion.	Weather.
																Direction	Force.		
1875.																			
Aug.	16th	22	Chong Tash...	...	60 0	—0·4	...	...	60 4	...	22 008	49·1	47·0	·303	87	Calm.	0	10	cc.
"	17th	4	" ...	...	...	...	...	...	...	...	21·998	48·1	46 0	·291	86	Calm.	0	10	cc.
"	"	8	Tadlik ...	9610	...	...	...	...	...	...	·124	53·6	47 0	·262	64	N.	...	...	cc.
"	"	10	" ...	...	...	...	...	...	...	...	·124	54·6	48·5	·285	67	N.	3	10	cc.
"	"	12	" ...	...	...	...	...	..	...	...	·102	55·6	49·0	·287	65	N.	...	...	cc.
"	"	16	" ...	..	...	...	...	...	...	...	·132	49·1	46 0	·283	81	Calm.	0	10	dr.
"	"	22	" ...	...	95·0	35·6	...	...	59·4	...	·189	47·1	45·0	·281	87	Calm.	0	10	dr.
"	18th	4	" ...	9,610	...	...	...	...	...	...	21·173	45·1	43·0	·259	86	Calm.	0	10	dr.
							44·4	0 6	...	45 0									
"	"	8	" ...	...	...	...	...	...	...	...	·185	45·6	43·5	·268	87	N.	...	...	cc.
"	"	10	? ..	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...
"	"	16	Kichik Yailak below Sanju Pass.	11,847	...	...	...	...	...	...	19·346	37·5	36·9	·215	95	Calm.	0	10	dr.
"	"	22	" ...	...	55 0	4·7	..	...	50 3	...	·417	35·0	33·9	·186	91	Calm.	0	10	dr.
"	19th	4	" ...	...	...	...	...	...	...	...	·393	34·9	33·9	·187	92	Calm.	0	10	dr.
							31·5	1·0	...	32 5									
"	"	8	" .	..	..	...	...	...	...	...	·402	36·0	35·4	·202	95	Calm.	...	...	dr.
"	"	10	" ..	...	...	...	...	...	...	...	·425	38·8	37·9	·221	93	N. W.	2	10	dr.
"	"	12	" .	..	.	..	...	...	...	...	·417	42·1	39 9	·228	85	N. N. W.	...	...	dr.
"	"	16	" ...	...	...	...	...	...	...	...	·423	37·5	36·7	·211	94	W.	4	10	dr.
"	"	22	" ...	..	85 5	42·7	...	...	42·8	...	·488	35·0	34·4	·194	95	Calm.	1	10	dr.
"	20th	4	" ...	.	...	...	...	...	...	...	·473	35 0	33·9	·186	91	Calm.	0	10	cc.
							32·0	2·1	...	34·1									
"	"	10	Sanju Pass ...	16,480 (16,760)	...	...	...	...	...	...	16·476	30 0	28·9	·151	91	E.	2	10	s.
"	"	16	Baz Chat ...	12,660	...	...	...	...	...	...	18 802	41·5	36 9	·182	69	N.	2	10	cc
"	"	22	" ...	...	52 0	10 2	...	...	41·8	...	·869	38 0	35·4	·186	81	Calm.	0	10	c.
"	21st	4	" ...	...	...	...	...	...	...	...	·859	35·0	31·9	·171	84	N.	2	10	c.
							32·0	2·1	...	34·1									
"	"	10	" ...	...	...	...	...	...	...	...									
"	"	12	Kurghan Ali Nazr.	10,690	...	...	...	..	...	...	20 385	65·1	47·0	·160	26	N. E.	...	6	b.
"	"	16	" ...	...	...	...	...	...	...	...	·347	58·1	44·0	·162	33	N.	5	8	b.
"	"	22	" ...	...	135·0	75·6	...	...	59 4	...	·419	49·1	42 0	·204	58	N.	2	10	cc.
"	22nd	4	" ...	...	...	...	...	...	...	...	·368	47·1	42 0	·223	69	W.	1	10	c.
							44·4	1·6	...	46 0									
"	"	10	" ...	...	...	...	...	...	...	...									

Results of observations recorded on the march between Yárkand in Kashgar and Murree in the Panjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (unscreened).	Sun radiation excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind Direction.	Wind Force.	Cloudy part of sky.	Weather.
1875.																			
Aug.	22nd	16	Toghrasu ...	11,150	...	...	...	...	...	...	19·945	60·6	44·5	·154	29	W. S. W.	2	10	cc.
"	"	22	" ...	...	102·5	33·1	...	...	69·4	...	20·026	52·6	42·0	·174	44	W. S. W.	2	10	cc.
"	23rd	4	" ...	...	...	...	...	...	...	...	·003	47·1	42·0	·223	69	E.	2	10	c.
							43·4	3·6	...	47·0									
"	"	10	Oibuk ...	11,630	...	...	...	...	...	...	19·633	60·1	45·0	·170	33	N.	4	2	Ks. l.
"	"	12	" ...	...	...	...	...	...	...	...	·606	64·1	46·5	·165	28	N.	..	2	Ks. b.
"	"	16	" ...	...	...	...	...	...	...	...	·523	66·1	50·0	·222	35	N.	3	6	Ks. b
"	"	22	" ...	...	139·5	68·1	...	...	71·4	...	·594	53·1	44·0	·210	52	N.	3	10	dr.
"	24th	4	" ...	...	...	...	...	...	...	...	·581	51·1	42·0	·189	50	N.	2	10	c.
				...	...	...	46·5	4·0	...	50·5									
"	"	8	" ...	...	...	...	...	...	...	...	·576	53·6	44·0	·206	50	N.	...	8	C. Ks. b.
"	"	10	" ...	...	...	...	...	...	...	...	·557	62·1	48·0	·214	38	N.	3	8	Ks. b.
"	"	12	" ...	...	...	...	...	...	...	...	·510	67·3	50·0	·212	32	N.	...	3	Ks. l.
"	"	16	" ...	...	...	...	...	...	...	...	·479	65·1	49·0	·209	34	N.	3	2	Ks. b.
"	"	22	" ...	...	134·0	65·6	...	...	68·4	...	·552	54·3	43·0	·181	43	N.	2	10	cc.
"	25th	4	" ...	...	...	...	...	...	...	...	·557	52·1	42·0	·181	46	N.	2	10	c.
							44·4	6·1	...	50·5									
"	"	10	Balakchi ...	11,880	...	...	...	...	...	...	·328	61·6	47·0	·198	36	Calm.	0	1	Ks. b.
"	"	12	" ...	...	...	...	...	...		...	·279	69·6	49·0	·172	24	N. W.	...	2	Ks. l.
"	"	16	" ...	...	...	...	...	...	...	...	·209	67·1	49·0	·194	29	N. W.	3	10	c.
"	"	22	" ...	...	143·0	67·1	...	...	75·9	...	·330	54·1	43·0	·184	44	N. W.	3	10	cc.
"	26th	4	" ...	...	...	...	...	...	...	...	·338	48·1	41·4	·201	61	Calm.	0	10	c.
							44·4	3·2	...	47·6									
"	"	10	Gulgan Shah Mazar.	12,250	...	...	...	...	...	...	·029	61·1	46·0	·159	27	N.	2	3	Ks. b.
"	"	12	" ..	...	...	...	...	...	...	...	·012	65·1	48·5	·203	33	N.	...	3	Ks. l.
"	"	16	" ...	...	...	...	...	...	...	...	18·973	63·1	46·0	·168	29	N.	3	6	Ks. l.
"	"	22	" ...	...	131·0	61·6	...	...	69·4	...	19·120	49·1	40·9	·187	53	Calm.	0	10	cc.
"	27th	4	" ...	...	...	...	...	...	...	...	19·137	39·0	36·9	·208	87	Calm.	0	10	dr.
							34·1	1·5	...	35·6									
"	"	8	" ...	...	...	...	...	...	...	...	·152	43·1	37·9	·185	66	N.	...	...	cc.
"	"	10	" ...	...	...	...	...	...	...	...	·146	47·1	39·9	·184	57	N.E.	1	8	Ks. l.
"	"	12	" ...	...	...	...	...	...	...	...	·103	56·1	44·5	·197	54	Calm.	...	9	Ks. b.
"	"	16	" ...	...	...	...	...	...	...	...	·035	53·1	43·0	·193	48	Calm.	0	10	f.
"	"	22	" ...	...	120·8	62·4	...	...	58·4	...	·176	41·0	38·9	·220	85	Calm.	0	10	cc.
"	28th	4	" ...	...	...	...	...	...	...	...	·171	39·0	37·9	·219	92	Calm.	0	10	dr.
							35·3	2·9	...	38·2									

Results of observations recorded on the march between Yárkand in Kashghar and Murree in the Panjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
Aug.	28th	8	Gulgan Shah Mazar.	12250	...	...	...	...	...	...	19·165	43·6	39·9	·216	76	Calm.	0	...	cc.
"	"	10	" ...	...	...	...	...	...	...	...	·159	52·1	43·0	·201	51	Calm.	0	10	cc.
"	"	12	" ...	...	...	...	...	...	...	...	·126	59·1	48·0	·242	48	Calm.	...	...	c.
"	"	16	" ...	...	...	...	...	...	...	...	·131	53·1	42·0	·174	43	N.N.W.	3	10	cc.
"	"	22	" ...	...	132·5	70·9	...	...	61·6	...	·213	45·1	39·9	·203	67	S.	2	10	cc.
"	29th	4	" ...	...	...	...	...	...	...	...	·241	32·5	30·9	·160	86	Calm.	0	0	b.
							26·0	5·5	...	31·5									
"	"	8	" ...	...	...	...	...	...	...	...	·253	49·1	43·5	·237	68	Calm.	...	1	Ks. b.
"	"	10	" ...	...	...	...	...	...	...	...	·236	56·0	45·0	·206	46	Calm.	0	1	Ks. b.
"	"	12	" ...	...	...	..	...	...	...	...	·205	61·1	45·0	·164	30	Calm.	...	1	Ks. b.
"	"	16	" ...	...	...	...	...	...	...	...	·124	63·1	45·0	·147	25	N.E.	4	1	Ks. b.
"	"	22	" ...	...	134·5	66·1	...	...	68·4	...	·179	45·1	37·9	·168	56	Calm.	0	10	cc.
"	30th	4	" ...	...	...	...	...	...	...	...	·203	33·5	31·9	·167	87	Calm.	0	0	b.
							29·5	4·0	...	33·5									
"	"	10	Portash ...	13,210 (12,520)	...	...	...	...	...	...	18·488	62·1	43·0	·120	21	N.E.	1	1	Ks. b.
"	"	12	" ...	...	...	...	...	..	...	...	·478	65·6	45·0	·132	21	N.	...	1	Ks. b.
"	"	16	" ...	...	...	...	...	...	. .	...	·463	62·1	45·0	·162	29	N.E.	2	7	Ks. b.
"	"	22	" ...	...	137·0	67·1	...	...	69·9	...	·602	46·1	37·9	·162	52	N.E.	3	10	c.
"	31st	4	" ...	...	...	...	...	...	...	...	·556	43·1	34·9	·137	49	N.	2	0	b.
							38·2	3·6	...	41·8									
"	"	10	Highest Pass of Portash.	16,860	...	...	...	...	...	...	16·174	43·1	30·9	·093	33	S.W.	4	2	Ks. b.
"	"	12	" ...	...	...	...	...	...	...	...	·163	48·1	33·9	·095	28	S.W.	...	2	Ks. m.
"	"	16	Balak Bachi or Akin.	...	...	...	...	...	...	...	·178	...	...	...	...	S.	4	4	Ks. b.
"	"	22	" in camp	16,380	...	...	...	...	...	...	·375	30·0	26·9	·124	74	S.	4	10	cc.
Sept.	1st	4	" ...	...	...	...	...	...	...	...	·362	29·0	27·9	·141	90	...	...	...	...
							19·0	6·8	...	25·8									
"	"	10	Lang Shah ...	...	...	...	...	...	...	...	·735	...	...	...	...	S.	4	10	cc.
"	"	16	Darwaza Sarighot.	15,800	...	...	...	...	...	...	·719	46·6	31·4	·072	23	W.	4	4	Ks. b.
"	"	22	" ...	...	97·0	48·7	...	...	48·3	...	·763	30·0	28·9	·151	91	Calm.	0	0	b.
"	2nd	4	" ..	...	...	...	...	...	...	...	·757	25·5	23·9	·117	86	E.	2	10	ss.
							23·0	2·0	...	25·0									
"	"	10	Brangsa.	16,820 (17,180)	...	...	...	...	...	...	·183	39·0	26·9	·069	29	W.	4	4	Ks. b.
"	"	12	" ...	...	...	...	...	...	...	...	·177	44·1	32·4	·102	35	W.	...	4	Ks. b.

Results of observations recorded on the march between Yárkand in Káshghár and Murree in the Panjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected.)	Sun radiation excess.	Nocturnal radiation.	Nocturnal radiation deficit.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
Sept.	2nd	16	Brangsa ...	...	...	...	...	...	...		16·187	42·6	31·9	·105	38	W.	4	2	Ks. *b*
„	„	22	„ ...	...	105·0	60·7	...	...	41·3	...	·223	25·0	23·9	·121	90	Calm.	0	0	*b.*
„	3rd	4	„ ...	...	...	...	...	...	...	...	·211	22·0	20·9	·105	89	Calm.	0	0	*b.*
							17·0	3·0	...	20·0									
„	„	10	Kárákoram Pass	18,230 (18,550)	...	...	...	...	...	...	15·101	...	...	...	...	W.	4	4	Ks. *b.*
„	„	12	„ ...	...	...	...	...	...	...	...	·392	33·5	29·9	·144	75	W.	...	3	Ks. *b.*
„	„	22	Daulat Beg Uldi	16,460 (16,790)	99·0	61·3	...	...	31·7	...	16·358	25·0	22·9	·109	81	Calm.	0	2	Ks. *b.*
„	4th	4	„ ...	...	...	...	...	...	...	...	·374	20·5	18·9	·093	85	Calm.	0	0	*b.*
							17·0	2·5	...	19·5									
„	„	10	Highest Pass of Daib Sang plains.	17,780 (18,450)	...	...	...	...	...	...	15·704	36·0	21·9	·064	30	S.	3	4	C.K.S. *b.*
„	„	22	Burtse ...	15,550 (15,920)	100·0	61·7	...	...	38·3	...	16·964	38·0	36·9	·211	92	Calm.	0	0	*b.*
Sept.	5th	4	„ ...	...	...	...	...	...	...	...	16·984	26·0	23·9	·113	81	N.	1	0	*b.*
							23·0	3·5		26·5									
„	„	10	Murgha ...	14,840 (15,190)	...	...	...	..	...	..	17·428	52·1	34·4	·066	17	W.	1	0	*b.*
„	„	12	„ ...	...	...	...	...	...	...	...	·414	55·1	34·9	·049	11	W.	...	0	*b.*
„	„	16	„ ...	...	...	...	...	...	...	...	·376	58·1	36·9	·058	12	W.	2	1	Ck. *b.*
„	„	22	„ ...	...	123·5	64·1	...	...	59·4	...	·380	42·1	29·9	·081	30	W.	2	2	Ks. *b.*
„	6th	4	„ ...	...	...	...	...	...	...	...	·370	30·0	26·9	·124	74	W.	2	0	*b.*
							24·0	5·0	...	29·0									
„	„	10	Sasser ...	15,160	...	...	...	...	...	...	·231	51·1	32·9	·050	13	N.	2	0	*b*
„	„	12	„ ...	...	...	...	...	...	...	...	·319	52·1	33·9	·057	15	S.	...	1	Ks. *b.*
„	„	16	„ ...	...	...	...	...	...	...	...	·149	56·1	36·9	·075	20	Calm.	0	3	Ks. *b*
„	„	22	„ ..	...	125·0	64·6	...	..	60·4	..	·185	43·1	29·9	·075	27	Calm.	0	0	*b.*
„	7th	4	„ ...	...	...	...	...	...	..	...	·200	38·0	31·9	·127	55	N.	2	10	*cc.*
							35·1	1·0	...	36·1									
„	„	8	Sasser Diwan	17,580	...	...	...	...	...	...	15·813	28·5	26·9	·135	87	W.	...	...	*s.*
„	„	10	„ ...	...	...	...	...	...	...	...	·791	31·0	28·9	·145	83	W.	4	10	*cc.*
„	„	22	Camp near Tuti Yailak.	15,370	...	...	...	...	...	...	17·012	41·0	37·9	·206	80	N.	2	3	Ks. b
„	8th	4	„ ...	...	...	...	...	...	...	...	16·994	35·0	29·9	·131	64	W.	2	0	*b.*
							27·0	8·0	...	35·0									
„	„	10	? ...	...	...	...	...	...	...	...									
„	„	12	Karawal Diwan	15,170	...	...	...	...	...	...	17·234	52·9	36·9	·099	25	S. S. E.	...	4	Ks. *b.*

Results of observations recorded on the march between Yárkand in Káshghár and Murree in the Punjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected.)	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
Sept.	8th	16	Changlung ...	10,840 (10,760)	...	...	...	...	...	...	20·031	73·1	46·0	·072	88	N. N. W.	2	1	Ks. *b.*
,,	,,	22	,, ...	...	...	...	...	...	...	...	·025	59·1	42·0	·117	23	Calm.	0	6	Ks. *b.*
,,	9th	4	,, ...	...	...	...	...	...	...	...	·041	56·1	42·0	·143	39	Calm.	0	4	C.Ks. *b.*
							45·4	10·0	...	55·4									
,,	,,	10	Panamik ...	10,558 (10,840)	...	...	...	...	...	...	·262	74·1	...	...	...	S.	2	4	C.Ks. *b.*
,,	,,	12	,, ...	...	...	...	...	...	...	...	·245	77·2	.	...	...	S.	...	4	
,,	,,	16	,, ...	...	...	...	...	...	...	...	·159	73·1	...	...	...	Calm.	0	7	Ks. *b.*
,,	,,	22	,, ...	...	147·5	70·3	...	...	77·2	...	·302	53·9	...	...	...	S.	2	10	*dr.*
,,	10th	4	,, ...	...	...	...	...	...	...	...	·318	47·1	...	...	...	N.	3	10	*dr.*
							44·4	2·1	...	46·5									
,,	,,	10	Taghar ...	10,230	...	...	...	...	...	...	·573	51·1	46·5	·275	73	Calm.	0	10	*cc.*
,,	,,	12	,, ...	...	...	...	...	...	...	...	·577	52·1	47·5	·287	73	Calm.	...	...	*dr.*
,,	,,	16	,, ...	...	...	...	...	...	...	...	·575	48·1	45·0	·272	81	Calm.	0	10	*dr.*
,,	,,	22	,, ..	...	63·0	8·7	...	...	54·3	...	·633	46·1	44·0	·270	86	Calm.	0	10	*dr.*
,,	11th	4	,, ...	...	...	...	...	...	...	...	·630	45·1	43·0	·250	83	Calm.	0	10	*dr.*
							43·4	1·1	...	44·5									
,,	,,	10	? ...	...	...	...	...	...	...	...									
,,	,,	12	Tsatti ...	10,610	...	...	...	...	...	...	·470	57·1	49·5	·287	61	S.	...	...	*cc.*
,,	,,	16	,, ...	...	...	...	...	...	...	...	·431	59·1	48·0	·235	47	Calm.	0	10	*m*
,,	,,	22	,, ...	...	113·0	51·6	...	...	61·4	...	·491	50·6	48·5	·323	87	Calm.	0	8	Ks. *c.*
,,	12th	4	,, ...	...	...	...	...	...	...	...	·506	47·1	45·0	·281	87	Calm.	0	10	*c.*
							40·3	6·2	...	46·5									
,,	,,	10	? ...	...	...	...	...	...	...	...									
,,	,,	12	Below Khardong Pass.	15,520	...	...	...	...	...	...	17·019	49·1	38·9	·161	46	E.	...	2	Ks. *b.*
,,	,,	16	,, ...	...	...	...	...	...	...	...	·091	45·1	35·1	·130	43	E.	1	1	Ks. *b.*
,,	,,	22	,, ...	...	110·0	56·7	...	...	53·3	...	·189	34·0	28·9	·123	63	S.	3	6	Ks. *b.*
,,	13th	4	,, ...	...	...	...	...	...	...	...	·200	29·0	24·9	·105	66	W.	3	0	*b.*
							24·0	4·5		28·5									
,,	,,	10	Khardong Pass.	17,790	...	...	...	...	...	...	15·833	27·0	24·4	·114	78	N.	2	0	*b.*
,,	,,	12	,, ...	...	...	...	...	...	...	...	·812	34·0	30·9	·153	78	N.	...	0	*b.*
,,	,,	22	Leh ...	11,503	135·0	...	...	...	...	...	19·829	48·1	38·9	·157	47	Calm.	0	0	*b.*
,,	14th	4	,, ...	...	...	...	...	...	...	...	19·843	44·1	36·4	·149	50	Calm.	0	0	*b.*
							39·7	0·6	...	40·3									

Results of observations recorded on the march between Yárkand in Káshghár and Murree in the Panjáb, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, deficit.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
Sept.	14th	8	Leh ...	...	...	...	...	...	...	...	19·861	51·1	45·0	·247	66	...	–	0	*b*
"	"	10	" ...	...	...	...	...	...	...	...	·883	55·1	42·0	·127	26	Calm.	0	0	*b*
"	"	12	"	...	...	...	...	...	...	...	·869	61·1	42·0	·071	12	...	...	0	*b.*
"	"	16	" ...	...	...	...	...	...	...	..	·758	68·1	48·5	·170	25	Calm.	0	0	*b.*
"	"	22	" ...	...	129·5	59·1	...	...	70·1	...	·768	50·6	38·9	·136	37	Calm.	0	0	*b*
"	15th	4	" ...	...	...	...	...	...	...	...	·767	45·1	35·1	·123	41	N.	1	0	*b.*
							40·8	0·5	...	41·3									
"	"	8	" ...	...	...	...	...	...	...	...	·803	49·1	40·9	·185	53	Calm.	...	0	*b*
"	"	10	" ...	...	...	...	...	...	...	...	·814	59·1	42·5	·128	25	S.	1	0	*b.*
"	"	12	" ...	...	...	..	...	...	...	...	·691	64·1	43·5	·104	17	W.	...	0	*b.*
"	"	16	" ...	...	...	...	...	...	...	...	·696	73·1	45·0	·119	15	Calm.	0	0	*b.*
"	"	22	" ...	...	134·0	55·6	...	...	78·4	...	·696	58·6	37·9	·019	10	...	...	...	...
"	16th	4	" ...	...	...		...	...	...	...	·736	42·1	34·9	·141	52	N.	1	0	*b.*
							41·3	0·5	...	41·8									
"	"	8	" ...	...	...	...	...	...	...	...	·735	50·1	39·9	·165	44	S.	...	0	...
"	"	10	" ...	...	...	...	...	...	...	...	·780	60·1	42·0	·110	21	Calm.	0	0	*b.*
"	"	16	" ...	...	...	...	...	...	...	...	·647	68·1	45·5	·107	16	Calm.	0	0	*b.*
"	"	22	" ...	...	133·0	59·6	...	...	73·4	...	·681	51·1	43·0	·208	55	Calm.	0	3	Ks. *b.*
"	17th	4	" ...	...	...	...	...	...	...	...	·706	48·1	42·0	·215	64	Calm.	0	10	*cc.*
							41·8	6·3	...	48·1									
"	"	10	" ...	...	...	...	...	...	...	...	·790	65·1	50·5	·240	39	Calm.	0	10	*c.*
"	"	16	" ...	...	...	...	...	...	...	...	·685	65·1	49·5	·219	35	Calm.	0	8	Ks. *b.*
"	"	22	" ...	...	139·0	68·1	...	...	70·9	...	·716	54·1	45·0	·221	53	Calm.	0	...	*c.*
"	18th	4	" ...	...	...	...	...	...	...	...	·726	49·1	42·0	·207	59	N.	1	6	C. Ks. *b.*
							43·2	5·4	...	48·6									
"	"	10	" ...	...	...	...	...	...	...	...	·826	64·1	50·5	·219	42	N.	1	1	Ks. *b.*
"	"	16	" ...	...	...	...	...	...	...	..	·709	67·1	48·0	·163	25	N.	1	3	C. Ks. *b.*
"	"	22	" ...	...	132·0	60·6	...	...	71·4	...	·718	51·6	43·0	·203	53	N.	1	7	Ks. Moon-light.
"	19th	4	" ...	...	...	...	..	...	...	...	·726	49·1	40·9	·185	53	Calm.	0	1	Ks.
							40·3	3·6	...	43·9									
"	"	10	" . .	...	...	...	...	...	...	...	·801	62·6	50·0	·252	44	Calm.	0	3	Ks. *b.*
"	"	16	" ...	...	...	...	...	...	...	...	·676	65·1	48·5	·197	32	W.	1	10	*c.*
"	"	22	" ...	...	126·5	55·3	...	...	71·2	...	·722	53·1	45·0	·230	57	Calm.	0	10	*c.*
"	20th	4	" ...	...	...	...	...	...	...	...	·730	46·1	40·9	·211	67	N.	1	1	C. Ks. *b.*
							40·3	3·6	...	43·9									
"	"	10	" ...	...	...	...	...	...	...	...	·777	62·1	50·0	·256	46	Calm.	0	10	*c.*

Results of observations recorded on the march between Yárkand in Káshghár and Murree in the Punjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875. Sept.	20th	22	Nimu ...	10,430	...	...	...	...	...	...	20·532	56·1	44·0	·180	40	Calm.	0	0	*Moon-light.*
"	21st	4	" ...	...	...	...	...	...	...	...	·598	47·1	39·9	·182	56	Calm.	0	0	*b.*
							36·6	3·7	...	40·3									
"	"	10	" ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
"	"	16	Saspol ...	10,240	...	...	...	...	...	...	·618	78·5	50·0	·104	11	Calm.	0	1	Ks. *b.*
"	"	22	" ...	...	136·5	55·1	...	...	81·4	...	·662	62·1	43·0	·104	19	Calm.	0	0	*Moon-light.*
"	22nd	4	" ...	...	...	...	...	...	...	...	·691	53·1	39·9	·125	31	Calm.	0	0	*b.*
							45·4	7·6	...	53·0									
"	"	10	Nurla ...	8,910	...	...	...	...	...	...	21·004	67·1	45·5	·109	16	E.	1	1	Ks. *b.*
"	"	16	" ...	...	...	...	...	...	...	...	20·859	79·1	55·1	·212	21	W.	1	4	Ks. *b.*
"	"	22	" ...	...	141·0	54·6	...	...	86·4	...	·894	69·1	49·0	·163	23	N.	2	0	*Moon-light.*
"	23rd	4	" ...	...	...	...	...	...	...	...	·909	58·1	46·0	·201	41	Calm.	0	0	*b.*
							45·4	11·9	...	57·3									
"	"	10	Lama 'Yuru' ..	11,300	...	...	...	...	...	...	19·822	61·1	50·0	·258	48	Calm.	0	1	Ks. *b.*
"	"	16	" ...	...	...	...	...	...	...	...	·829	53·6	45·5	·235	57	S.	1	10	*m.*
"	"	22	" ...	...	80·0	17·8	...	...	62·2	...	·836	45·6	43·0	·256	83	N.	2	10	*cc.*
"	24th	4	" ...	...	...	...	...	...	...	...	·820	46·1	40·9	·210	67	N.	1	10	*cc.*
							43·6	4·5	...	48·1?									
"	"	8	Foto Pass ...	13,310	...	...	...	...	...	...	18·380	46·6	40·4	·201	63	N. N. W.	...	...	*cc.*
"	"	10	" ...	...	...	...	...	...	...	...	·398	53·1	42·5	·187	46	S.	3	10	*cc.*
"	"	16	Bod Kherbo...	11,350	...	...	...	...	...	...	19·697	59·1	46·0	·197	39	Calm.	0	10	*cc.*
"	"	22	" ...	...	105·0	39·6	...	...	65·4	...	·768	48·1	45·0	·273	81	Calm.	0	10	*dr.*
"	25th	4	" ...	...	...	...	...	...	...	...	·751	48·1	44·0	·253	75	W.	3	10	*cc.*
							42·3	5·3	...	47·6									
"	"	8	Namika Pass...	12,520	...	...	...	...	...	...	18·982	46·1	40·9	·213	68	W.	...	...	*cc.*
"	"	10	" ..	...	...	...	...	...	...	...	·959	50·1	43·0	·218	60	W.	4	10	*cc.*
"	"	16	Shergol	10,500	...	...	...	...	...	...	20·363	60·1	44·0	·144	28	S. E.	3	10	*m.*
"	"	22	" ...	...	78·0	15·6	...	...	62·4	...	·384	54·6	46·0	·234	55	S. E.	3	10	*dr.*
"	26th	4	" ...	...	...	...	...	...	...	...	·380	45·1	40·9	·219	73	S. E.	3	10	*dr.*
							43·4	2·1	...	45·5									
"	"	10	" ...	...	...	...	...	...	...	...	...	46·1	44·0	·271	87	Calm.	0	10	*dr.*
"	"	16	" ...	...	...	...	...	...	...	...	...	39·5	38·4	·225	93	S. S. E.	3	10	*dr.*
"	"	22	" ...	...	56·5	8·2	...	...	48·3	...	·529	43·1	39·9	·218	78	S. S. E.	2	10	*Star-light.*
"	27th	4	" ...	...	...	...	...	...	...	...	·538	44·6	42·0	·244	83	Calm.	0	10	*cc.*
							39·2	0·0	...	39·2									
"	"	16	Karghil ...	8,840	...	...	...	...	...	...	21·747	63·1	50·0	·236	44	Calm.	0	2	Ks. *b.*

Results of observations recorded on the march between Yarkand in Kashghar and Murree in the Panjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
Sept.	27th	22	Karghil ...	...	110·5	41·1	...	...	69·4	...	21·778	53·1	46·0	·213	60	Calm.	0	0	*Star-light.*
„	28th	4	„ ...	...	...	...	...	...	...	...	·801	47·6	44·0	·251	77	Calm.	0	0	*l.*
							42·3	4·2	...	46·5									
„	„	22	Kherbo of Dras	9,270	...	...	...	...	...	...	·159	55·1	44·0	·153	42	S.	1	0	*Star-light.*
„	29th	4	„ ...	...	...	...	...	...	...	...	·172	47·6	40·9	·193	58	Calm.	0	0	*l.*
							43·2	4·7	...	47·9									
„	„	16	Dras ...	10,100	...	...	...	...	...	...	20·675	72·1	49·0	·136	17	W.	2	6	K*e.* *l.*
„	„	22	„ .	...	132·5	56·1	...	...	76·1	...	·718	53·1	44·0	·206	51	W.	2	0	*Star-light.*
„	30th	4	„ ..	...	...	...	...	...	...	...	·712	40·0	36·9	·192	77	Calm.	0	0	*l.*
							32·0	8·3	.	40·3									
„	„	10	Matain ...	10,550	...	...	...	...	...	...	·299	59·1	45·0	·173	34	W.	3	1	K*e.* *l.*
„	„	16	„ ...	...	...	...	...	...	...	...	·298	56·1	43·0	·161	36	S. S. E.	3	8	C. K*e.* *l.*
„	„	22	„ ..	...	133·5	64·1	...	...	69·4	...	·334	49·1	41·4	·193	55	S. E.	3	10	*cc.*
Oct.	1st	4	„ .	...	...	...	...	...	...	...	·336	45·1	39·9	·201	67	W.	2	0	*l.*
							31·0	12·4	...	43·1									
„	„	10	Zoji Pass ...	11,310	...	...	...	...	..	...	19·801	47·1	41·4	·211	65	W.	2	10	*cc.*
„	„	12	„ ...	...	.	...	...	...	..	..	·802	49·1	44·0	·245	70	W.	...	...	*cc.*
„	„	16	Baltal ...	9,360	...	...	...	...	.	...	21·231	50·1	48·0	·316	87	W. S. W.	1	10	*dr.*
„	„	22	„ ..	.	69·5	11·8	...	..	57·7	...	·270	46·1	45·0	·290	93	Calm.	0	10	*dr.*
„	2nd	4	„ ...	...	...	...	...	...		...	·258	39·0	37·9	·217	91	E.	2	10	*cc.*
							33·0	4·2	.	37·2									
„	„	10	Shita Kari ...	8,420	...	...	..	..	..	...	22·039	43·1	39·9	·217	78	W.	2	10	*m. r.*
„	„	16	„ ..	..	...	..	...	...	..	..	·016	46·1	44·0	·268	86	Calm.	0	10	*dr.*
„	„	22	„ .	...	111·5	56·2	...	..	55·3	.	·057	41·5	40·4	·242	92	Calm.	0	10	*dr.*
„	3rd	4	„ ..	...	...	..	...	...	. .	...	·035	38·0	35·9	·191	83	E.	1	10	*cc.*
							31·1	3·1	37·2										
„	„	10	Kalan .	7,160	...	...	...	...	...	...	23·136	49·1	47·0	·302	86	S.	1	10	*cc.*
„	„	16	„ ...	....	...	. .	...	...		.	·136	45·1	44·5	·289	96	Calm.	0	10	*dr. r.*
„	„	22	„ ...	...	55·0	4·7	...	...	50·3	...	·162	42·1	41·4	·255	95	Calm.	0	10	*cc.*
„	4th	4	„ ...	...	...	...	...	...	...	..	·110	40·0	37·9	·207	83	E.	1	10	*cc.*
„	„	10	Kanggan ...	5,780	...	...	...	..	...	39·2	24·402	55·1	50·0	·307	70	W.	3	10	*cc.*
„	„	16	„ ...	...	...	...	...	...	...	...	24·254	56·1	51·0	·320	71	W.	1	10	*cc.*
„	„	22	„ ...	...	109·0	47·6	...	...	61·4	...	·272	49·1	48·0	·324	93	Calm.	0	10	*cc.*
„	5th	4	„ ...	...	...	...	...	...	...	...	·211	45·1	43·0	·256	85	Calm.	0	10	*dr.*
							43·4	2·1	...	45·5 ?									
„	„	10	Gondar Bal ...	5,110 ?	...	...	...	...	...	...	·865	53·6	50·0	·322	78	W.	2	10	*cc.*

Results of observations recorded on the march between Yárkand in Káshghár and Murree in the Punjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected).	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875.																			
Oct.	5th	16	Gondar Bal ...	...	.	...	..	...	...	...	24·836	49·1	47·0	·301	86	Calm.	0	10	*dr.*
"	"	22	" ...	...	80·0	24·7	...	..	55·3	...	·860	45·1	43·5	267	89	Calm.	0	10	*dr.*
"	6th	4	" ...	...	...	...	...	...	...	...	·852	46·1	44·0	·266	85	Calm.	0	10	*c.*
							43·4	1·1	...	44·5									
"	"	10	Nasim Bagh ..	...	...	...	...	...	...	...	·908	50·1	47·5	·301	83	Calm.	0	10	*c.*
"	"	16	Srinagar ...	5,250	...	...	...	...	...	...	·895	46·1	45·0	·288	92	Calm.	0	10	*dr.t.lr.16*
"	"	22	" ..	...	58·0	...	...	...	...	...	·878	43·1	42·0	·256	92	Calm.	0	10	*c.*
"	7th	4	" ...	...	...	...	.	...	...	...	·883	40·0	35·9	·167	67	Calm.	0	5	C. Ks. *b.*
							33·8	3·4	...	37·2									
"	"	10	" ...	...	...	...	...	...	...	...	·936	54·6	50·0	·311	73	Calm.	0	10	*c.*
"	"	16	" ..	...	...	...	...	...	...	...	·883	56·1	49·5	·283	63	Calm.	0	10	*c.*
"	"	22	" ...	...	116·0	55·6	...	...	60·4	...	·920	43·1	42·0	·256	92	Calm.	0	10	*sl.*
"	8th	4	" ...	...	...	...	...	...	...	...	·937	38·0	34·9	·170	74	Calm.	0	0	*b.*
							34·1	1·5	...	35·6									
"	"	10	" ...	...	...	...	...	...	...	...	·989	57·1	49·0	·259	55	Calm.	0	0	*bb.*
"	"	16	" ...	...	..	...	...	...	...	...	·902	62·6	51·5	·259	46	Calm.	0	0	bb.
"	"	22	" ...	...	115·0	44·6	...	...	70·4	...	·961	45·1	43·0	·256	85	Calm.	0	0	*sl.*
"	9th	4	" ...	...	...	...	...	...	...	...	·944	40·0	37·9	·206	83	Calm.	0	0	*bb.*
							35·1	2·1	...	37·2									
"	"	10	" ..	...	...	...	...	...	...	...	25·014	56·3	50·0	·292	52	Calm.	0	0	*bb.*
"	"	16	" ..	...	...	...	...	...	...	...	24·910	64·1	51·0	·230	38	Calm.	0	1	Ks. *bb.*
"	"	22	" ..	...	120·5	45·6	...	...	74·9	...	·946	46·1	44·0	·266	85	Calm.	0	0	*sl.*
"	10th	4	" ..	...	...	...	...	...	...	...	·977	37·5	35·9	·195	87	Calm.	0	0	*bb.*
							31·5	5·7	...	37·2									
"	"	10	On boat floating in Jhilam	5,235	..	...	...	...	...	...	25·009	52·1	45·5	·233	60	Calm.	0	0	*bb.*
"	"	16	" ...	[By trig.]	...	...	...	...	...	...	24·912	67·6	52·0	·216	32	Calm.	0	5	Ks. *bb.*
"	"	22	" ...	...	114·0	40·6	...	...	73·4	...	25·010	48·6	45·0	·270	79	W.	2	0	*Moonlight.*
"	11th	4	" ...	...	.	...	...	...	...	...	·010	38·5	35·9	·183	78	Calm.	0	0	*bb.*
							30·0	8·2	...	38·2									
"	"	16	Rampur ...	4,890	...	...	...	...	...	...	·259	70·1	51·0	·161	22	E. N. E.	1	1	Ck. *b.*
"	"	22	" ...	...	119·0	40·6	...	...	78·4	...	·338	46·1	42·0	·222	71	E. N. E.	1	0	*Moonlight.*
"	12th	4	" ...	...	...	...	...	...	...	...	·316	45·6	40·4	·191	63	E.	2	0	*b.*
							38·2	7·3	...	45·5									
"	"	10	Ori ...	4,460	...	...	..	...	...	...	·580	62·1	51·5	·262	47	E.	1	0	*b.*

Results of observations recorded on the march between Yárkand in Káshghár and Murree in the Panjab, by Dr. J. Scully and Assistants—continued.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (unscreened).	Sun radiation excess.	Nocturnal radiation.	Nocturnal radiation deficit.	Maximum thermometer.	Minimum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension.	Humidity.	Wind Direction.	Wind Force.	Cloud proportion.	Weather.
1875.																			
Oct	12th	16	Ori ...	...	...	...	...	...	...	...	25·517	76·2	54·0	·167	18	W.	1	1	C. b.
"	"	22	" ...	...	130·5	51·1	...	...	79·4	...	·611	51·1	46·0	·243	65	W.	2	0	Moonlight.
"	13th	4	" ...	...	...	...	...	...	...	...	·606	46·1	42·0	·221	71	E.	3	0	l.
							40·8	5·2	...	46·0									
"	"	10	Chakoti ...	4,160	...	...	...	...	...	...	26·143	71·1	51·0	·142	19	N.	1	2	Ks. b.
"	"	16	" ...	...	...	...	...	...	...	...	·122	68·6	57·1	·331	48	S. W.	1	6	C. Ks. l.
"	"	22	" ...	...	125·5	51·1	...		74·4	...	·235	55·1	50·0	·302	69	Calm.	0	0	Moonlight.
"	14th	4	" ...	...	...	...	...	...	...	...	·223	52·1	46·5	·253	65	E. N. E.	1	0	l.
							49·0	3·5	...	52·5									
"	"	10	Hattian ...	3,060	...	...	...	...	...	...	·968	65·1	54·0	·286	46	Calm.	0	0	l.
"	"	16	" ...	...	...	...	...	...	...	...	·899	79·2	60·1	·291	29	W.	1	0	l.
"	"	22	" ...	...	121·0	42·1	..	...	81·9	...	27·034	53·1	50·0	·326	80	Calm.	0	0	Moonlight.
"	15th	4	" ...	...	...	...	...	...	...	...	·034	52·6	48·5	·293	74	S.	1	0	l.
							49·5	3·0	...	52·5									
"	"	10	Garhie ...	2,650	...	...	...	...	...	...	·358	67·6	55·1	·281	42	Calm.	0	0	l.
"	"	16	Tanhali ...	2,500	...	...	...	...	.	...	27·529	77·2	62·7	·391	42	Calm.	0	0	l.
"	"	22	" ...	...	120·0	33·6	...	...	86·4	...	·596	59·1	55·1	·387	77	N. W.	1	0	Moonlight.
"	16th	4	" ...	...	...	...	...	...	..	...	·592	53·6	51·0	·343	83	S.	1	0	ll.
							49·5	3·5	..	53·0									
"	"	10	Rara ...	2,170	...	...	...	...	...	...	·827	66·1	56·6	·342	53	N.	1	0	ll.
"	"	16	" ...	...	...	...	...	...	...	...	·747	78·2	65·2	·460	48	N.	1	0	bl.
"	"	22	" ...	...	129·5	44·1	...	...	85·4	...	·841	60·1	57·1	·431	83	Calm.	0	0	Moonlight.
"	17th	4	" ...	...	...	...	...	...	..	...	·836	55·1	52·0	·351	81	N.	1	0	l.
							51·5	3·4	...	54·9									
"	"	10	Chattar ...	2,110	...	...	...	...	...	...	·911	61·6	57·6	·427	78	N.	1	2	Ks. l.
"	"	16	Kohala ...	2,110	...	...	...	...	...	...	·908	69·6	65·2	·568	78	Calm.	0	5	C. Ks. l.
"	"	22	" ...	...	131·0	42·6	...	...	88·4	...	·998	62·1	60·1	·496	89	Calm.	0	10	dr.
"	18th	4	" ...	...	...	...	...	...	...	..	28·039	59·1	55·1	·386	77	Calm.	0	10	cc.
							55·4	3·4	...	58·8									
"	"	10	Daiwal ...	4,970	...	...	...	...	...	...	25·180	60·1	53·5	·331	64	Calm.	0	4	Kr. l.
"	"	16	" ...	...	...	...	...	...	...	...	·138	70·6	54·0	·219	29	Calm.	0	6	C. Ks. b.
"	"	22	" ...	...	124·0	45·6	...	...	78·4	...	·162	57·6	49·0	·215	51	E.	1	0	Moonlight.
"	19th	4	" ...	...	...	...	...	...	...	...	·126	57·1	47·5	·214	46	Calm.	0	0	l.
							48·5	5·9	...	54·4									
"	"	10	Murree ...	7,440	...	...	...	...	...	...	23·011	57·6	46·5	·183	38	E.	1	0	l.
"	"	16	" ...	...	...	...	...	...	...	...	22·972	59·1	50·0	·232	50	Calm.	0	0	l.

Results of observations recorded on the march between Yárkand and Káshghár and Murrèe in the Punjab, by Dr. J. Scully and Assistants—concluded.

Month.	Day.	Hour.	Station.	Approximate elevation.	Sun thermometer (uncorrected.)	Sun radiation, excess.	Nocturnal radiation.	Nocturnal radiation, defect.	Maximum thermometer.	Maximum thermometer.	Pressure reduced to 32°.	Dry Bulb thermometer.	Wet Bulb thermometer.	Vapour tension	Humidity.	Wind. Direction.	Wind. Force.	Cloud proportion.	Weather.
1875. Oct.	19th	22	Murree	...	120·0	53·6	...	...	66·4	...	22·974	52·1	42·0	·146	24	E.	1	0	*Moon-light.*
,,	20th	4	,, ...	...	...	...	...	...	...	...	·948	49·6	39·9	·131	37	N.	2	0	*b.*
							37·2	11·4	...	48·6									
,,	,,	10	,, ..	...	...	...	...	...	...	...	·937	57·1	50·0	·277	59	S.	1	0	*b.*
,,	,,	16	,, ...	...	...	...	...	...	...	...	·987	58·1	50·0	·264	54	S.	1	0	*b.*
,,	,,	22	,, ..	...	114·0	51·6	...	...	62·4	...	23·012	51·1	44·0	·203	54	Calm.	0	0	*Star-light.*

Boiling-point Observations.

It has been mentioned at page 213 that on the journey from Leh to Káshghár, a large number of boiling-point readings were made simultaneously with those of a compared mercurial barometer. They have not been utilised for determining elevations, inasmuch as they indicate only indirectly, and with much inferior accuracy, that which is shown directly and with great accuracy by the barometer. But it will be not without interest, to compare the pressures computed from the boiling-points with the barometric readings. The pressures have been computed in the following mann er :—A table of the elastic pressures of water-vapour for each tenth of a degree between 180° and 205° Fahr. was computed for the sea-level in Lat. 36° by applying a gravity correction to the values of Tables I and III in Dixon's Treatise on Heat, the corrections being obtained by the same formula as that employed by Dr. Dixon; and a further correction for the altitude of each station was then applied to the tabular vapour tension of each individual reading. The results are given in the following table, which shows the elevations of the stations, the observed boiling-points, the computed and observed pressures, and the difference or error of the computed pressure.

Comparative Table of observed pressures and pressures computed from boiling-points.

Stations.	Elevations.	B. P.	Computed pressure.	Observed pressure.	Error.
Leh	11,503	191·6	19·687	19·683	+·004
,, ...	...	191·9	·812	·688	+·124
,, ...	...	192·0	·855	·688	+·167
Camp above Goules	...	187·8	18·146	18·338	−·192
,, ...	...	188·6	·462	·433	+·029
,, ...	...	188·5	·422	·433	−·011
Khardong Pass	17,790	180·8	15·572	15·615	−·043
,, ...	...	180·9	·607	·633	−·026

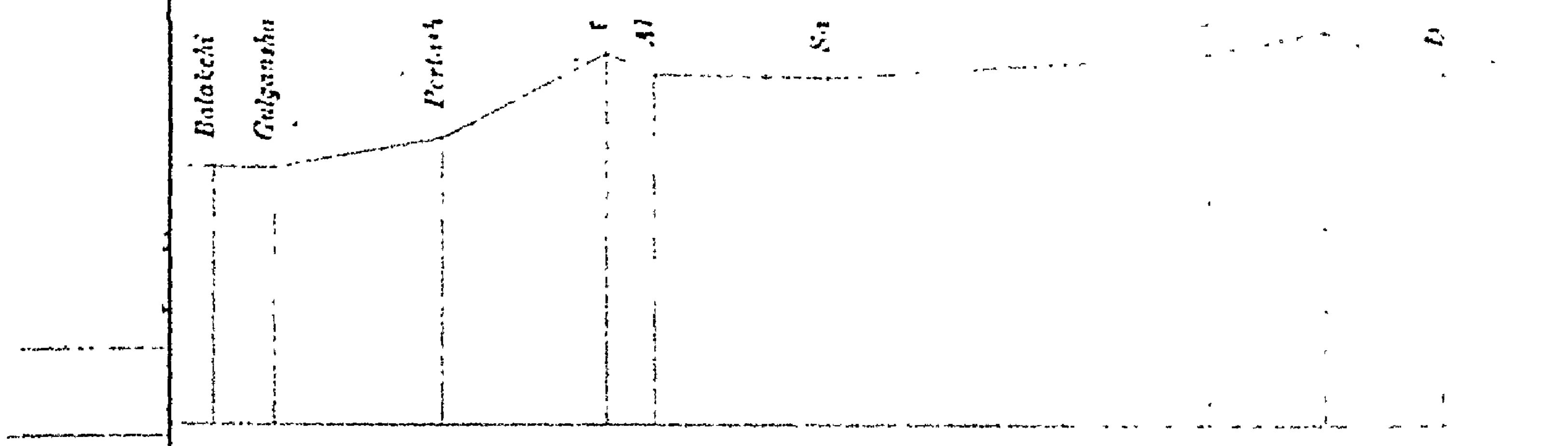
Comparative Table of observed pressures and pressures computed from boiling-point data—continued.

Stations	Elevation.	B. P.	Computed pressure.	Observed pressure.	Diff.
Village of Khardong	...	187·8	18·942	18·777	+·165
"	...	190·1	19·065	·777	+·288
Camp Tratti	10,610	192·8	20·194	20·286	−·092
" "	...	193·1	·323	·432	−·109
" "	..	193·2	·365	·432	−·067
Camp Taghar	10,230	193·3	·408	·486	−·078
" "	...	193·7	·582	·630	−·048
Camp Panamick	10,810	192·9	·237	·320	−·083
" "	...	193·3	·408	·426	−·018
" "	...	193·1	·323	·433	−·110
" "		193·3	·408	·470	−·062
Changlung	10,760	192·4	·023	·087	−·064
"	.	192·5	·065	·133	−·068
Karawal Diwan Pass	15,170	185·1	17·113	17·226	−·113
" "	...	185·2	·150	·226	−·076
Tuti Yailak	15,370	186·3	·568	·686	−·118
"	...	186·3	·568	·729	−·161
Sarthang	.	182·6	16·203	16·310	−·107
"	.	182·6	203	·315	−·112
"	...	182·7	·239	·349	−·110
Sasser Pass	..	181·0	15·641	15·635	+·006
Camp Sasser	.	184·9	17·040	17·139	−·099
" Murgha	15,190	185·7	·340	·279	+·061
" "		185·8	·377	·422	−·045
Burtse	15,920	184·8	17·005	16·830	+·175
"	.	184·9	·042	·851	+·191
Kizil Ungur	...	183·0	16·346	·378	−·032
"	.	182·95	·328	·428	−·100
Daulat Beg Uldi	16,790	182·4	·132	·274	−·142
"	...	182·55	·186	·288	−·102
Karakoram Pass	18,550	179·6	15·164	15·327	−·163
Balti Brangsa	17,180	182·4	16·132	16·205	−·073
Darwaza Sirighat	15,800	183·8	·634	·788	−·154
" "	...	183·9	·671	·798	−·127
Chibra	...	182·0	15·990	·093	−·103
Suget Pass	...	180·6	·504	15·555	−·051
Camp Suget	...	188·4	18·382	18·442	−·060
Shahid-ul-lah	...	190·2	19·094	19·273	−·179

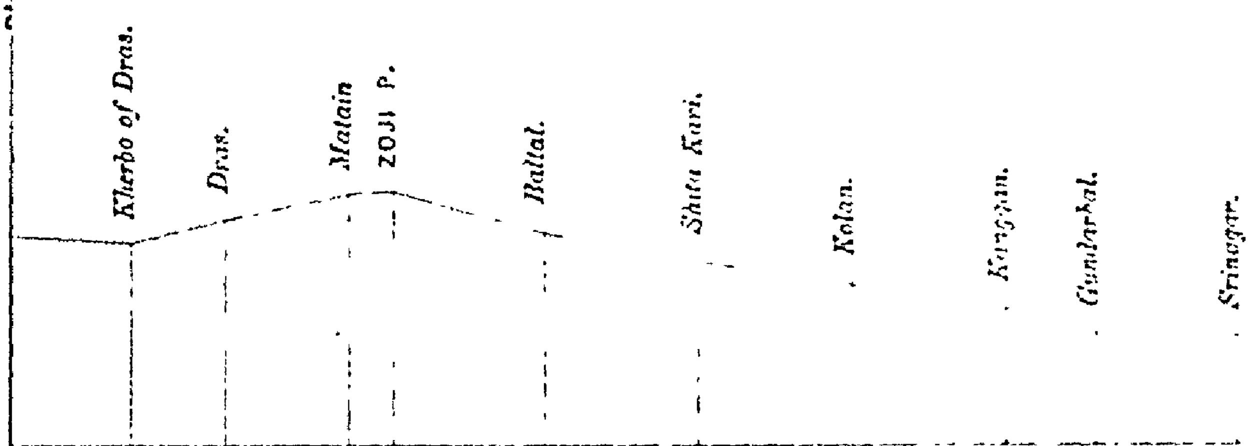
Comparative Table of observed pressures and pressures computed from boiling-points—concluded.

Stations.	Elevations.	B. P.	Computed pressure.	Observed pressure.	Error.
Shahid-ullah	...	191·6	19·436	19·573	−·137
"	...	190·95	·415	·529	−·114
"	...	191·2	·519	·545	−·026
Toghrasu	11,150	192·4	20·025	·934	+·091
Kurghan Alinazar	10,590	192·8	·194	20·297	−·103
" "	...	193·4	·452	·341	+·111
Tarbughoz	...	186·9	17·795	17·907	−·112
Sanju Pass	16,760	182·8	16·275	16·352	−·077
"	...	182·7	·239	·346	−·107
Kichik Yailak	11,847	190·75	19·333	19·349	−·016
" "	...	190·8	·353	·349	+·004
Tam	...	196·8	21·971	21·772	+·199
"	...	196·7	·926	·772	+·154
Kewis	...	198·45	22·736	22·824	−·088
"	...	198·6	·808	·894	−·086
Sanju	6,070	200·2	23·578	23·723	−·145
"	...	200·7	·824	·872	−·048
"	...	200·5	·724	·806	−·082
Salik Aziz Langar	6,190	201·95	24·445	24·182	+·263
" "	...	201·6	·270	·144	+·126
Koshtak	5,970	201·55	·245	·226	+·019
Oi Toghrak	...	202·1	·521	·259	+·262
Bora	5,340	202·15	·543	·556	−·013
"	...	202·25	·594	·556	+·038
"	...	202·1	·518	·638	−·120
Karghalik	4,440	203·7	25·337	25·441	−·104
"	...	203·9	·441	·549	−·108
Posgam	...	204·7	·856	·772	+·084
"	...	204·85	·936	·874	+·062
Yangi Shahr Yarkand	...	204·6	·803	26·013	−·210
" "	...	204·55	·777	·013	−·236
" "	...	204·6	·803	·060	−·257
Kokrabat	...	204·9	·962	25·947	+·015
Kizil	...	204·5	·752	·809	−·057
Yangi Hissar	...	205·1	26·068	·938	+·130
Toghlok	...	204·55	25·777	·956	−·179
Yangi Shahr Kashghar	...	204·2	·594	·767	−·173
" "	...	204·45	·725	·905	−·180
" "	...	204·4	·699	·905	−·206

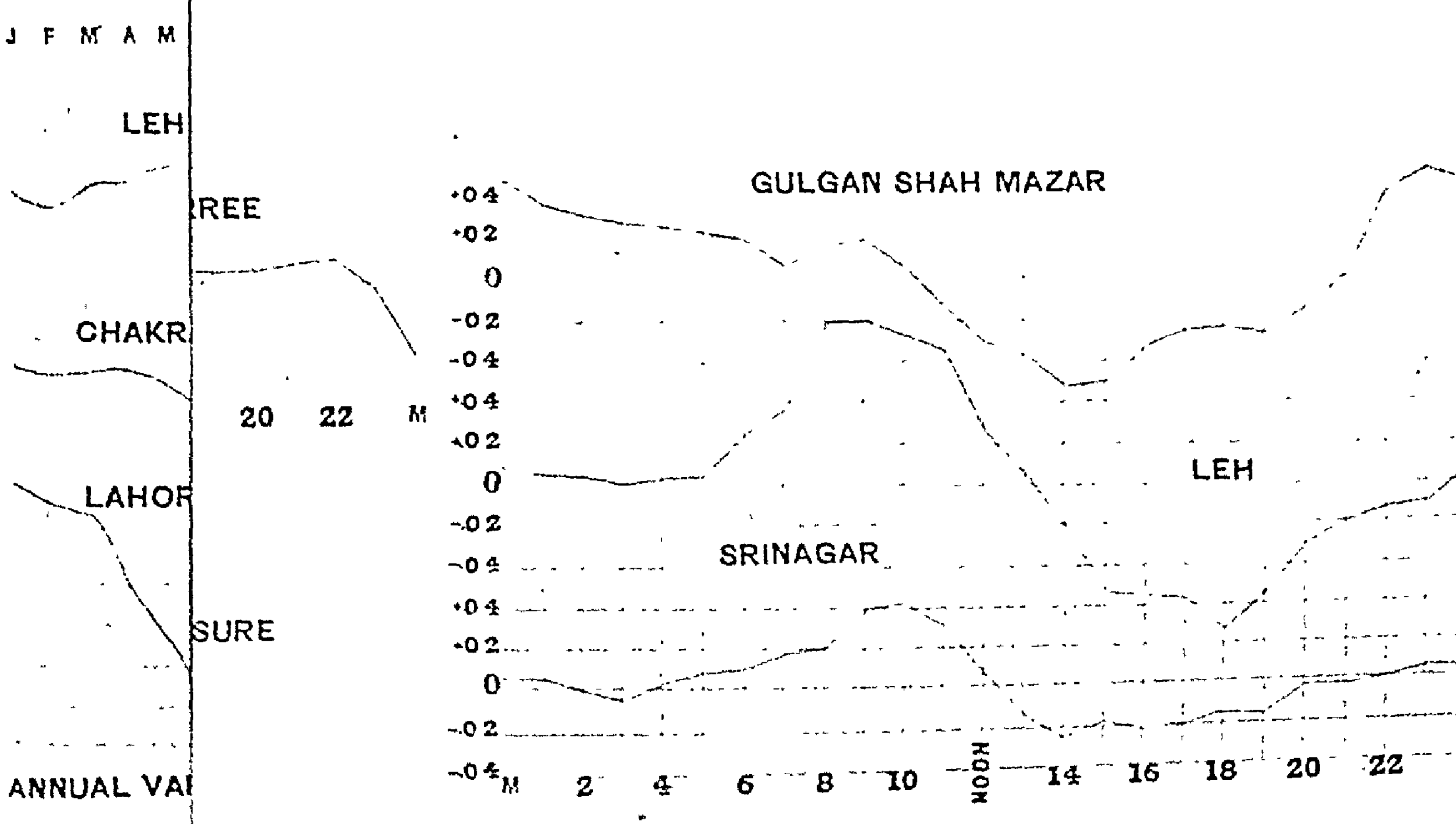
Gov't, Central Press.—No. 119 G. M.—22-8-79.—400.



RAS VALLEY. SIND VALLEY.



FROM YARKAND TO SRINAGAR.



Litho. T. C. Press, D

IX.—*The winds of Kurrachee, by* FRED. CHAMBERS, ESQ., *Meteorological Reporter for Western India.*

The observations which form the principal subject of the following discussion were furnished by a Robinson-Beckley anemograph, which has been at work for several years at Kurrachee, under the supervision of W. H. Price, Esq., M.I.C.E., Superintendent of the Kurrachee Harbour Works. The instrument was constructed by Adie of London, and was procured from England for the purpose of investigating the influence of the wind on the tides at Kurrachee. A suitable site was chosen on a narrow spit of land, which separates the harbour from the open sea and terminates in Manora Point. On this site, a small cylindrical tower, about 6 feet high and 6 feet in diameter, surmounted by a dome, was erected specially for the anemograph, the cups of which are 15·65 feet above the ground. The only objects which very sensibly overtop the instrument are, the church to the east-south-east, and the light-house to the south-east, both of which have angular elevations, as seen from the anemograph, of less than 2°, at distances of 1,840 and 3,420 feet respectively. The instrument itself is, generally speaking, of the same size and pattern as those in use at the Government Meteorological Observatories in the British Isles, a full description of which is to be found in the Report of the Meteorological Committee of the Royal Society for the year 1867. The Kurrachee instrument was, however, unprovided with the usual small accessories to facilitate accurate adjustment for time and direction, and consequently in both these particulars its indications have been somewhat rough. Moreover, the wind-mill vanes were found on trial to be wanting in responsiveness to variations in the direction of light winds, and a large arrow-shaped vane of the ordinary description was therefore substituted. This seems to have worked well, and to have been remarkably free from any tendency to oscillate extravagantly during high winds.

The observations used are those furnished by the anemograms for the three years 1873, 1874, and 1875, which have been kindly placed at my disposal for discussion by Mr. Price, who has already published the observations in considerable detail in the *Sind Official Gazette*, in a form different from that herein adopted. The velocity trace has been read to the nearest mile, and tabulated at half-past each hour, so that the hourly velocities recorded are those observed from half an hour before to half an hour after, each full hour. In tabulating the direction of the wind, the circle has been divided into sixteen parts, and the directions recorded are those indicated by the instrument during the hourly intervals corresponding to those of the recorded velocities. A glass plate, on which half-hour lines had been etched at equidistant intervals, was used for this purpose, the hour lines of the anemogram forms being disregarded, as it was found that they were not in every case equidistant. The instrument was arranged to produce a continuous record on the same paper for forty-eight hours,

and the papers were changed every alternate day, about noon. Until the 25th June 1873, it was the practice to reset the velocity pencil to zero, and the direction pencil to north, after pointing the vane to a fixed reference mark in that direction. The time occupied by this process, and the troublesomeness of the means of adjustment, usually caused a sensible portion of the trace to be lost. In these cases, the lost portion has been interpolated by continuing onward the traces of one paper, and backward those of the other; but whenever from stoppage of the clock or other causes, the traces have been lost for several hours, the remaining incomplete portions for that day have been rejected. No attempt has been made to correct for friction.

The tabulated velocity and direction observations of each hourly interval have been resolved into their equivalent north and east components; and daily, monthly, half-yearly, and yearly averages of these have been calculated for each year. The results are contained in tables I to VI. Table VII gives for each hour of the day, and for the whole day, the monthly, half-yearly, and yearly averages for the three years combined; and table VIII gives the corresponding hourly *inequalities*. The hourly numbers of tables VII and VIII are graphically represented by figures 1 to 15; in such a manner, that imaginary straight lines, drawn from the zero points[1] of each figure to the hour points of the same figure, will show, by their direction, the resultant direction from which the wind blows; and, by their length, the resultant velocity of the wind (in miles per hour) at each particular hour. The figures show, at a glance, the manner in which the wind in each month varies from hour to hour; in other words, they show the *diurnal* variations of the wind in each month of the year. The straight lines, drawn from the zero points to the middle points[2] of each figure, similarly represent the resultant winds of each month, and imaginary straight lines, drawn from each of these middle points to the respective hour points of the figure in which it is placed, indicate the hourly *inequalities* of the wind in each month. Figure 76 shows, in a similar manner, how the winds vary from month to month; or, in other words, it represents the *annual* variation of the wind; the same units of length and time (mile and hour) being still retained. The straight line drawn from the zero point (enclosed in a small circle) to the middle point of the figure represents the resultant wind of the whole year. The diurnal inequalities of the north and east components separately, are also represented by figures 16 to 45. These figures show the respective variations with regard to time, more distinctly than figures 1 to 15, and lead to the detection of important features which are apt to be overlooked in the latter curves. Table IX contains, for each hour of the day and the whole day the mean velocity of the wind (in miles per hour and regardless of direction) in each month, each half-year, and in the whole year, these results being the averages obtained by combination of the observations of the three years. Figures 46 to 60 graphically represent these numbers.

Annual Resultant and Annual Variation of the wind.—These are represented by figure 76, from which it will be seen that the variations of the wind from month to month, at Kurrachee, are of a simple character. In December the wind blows from N23°E. with a velocity of 5 miles per hour. From December onward, its direction gradually passes through north round by west, to S60°W. in the month of July;

[1] The points surrounded by small circles, thus ⊙.

[2] The points enclosed by dots, thus ⁂

when its velocity is 22 miles per hour. It then gradually returns through west and north to the direction N23°E. The annual resultant wind has a velocity of 12 miles per hour from S72°W. The resultant wind of any month is such that it may be regarded as approximately composed of the annual resultant, *plus* a wind from N57°E or S57°W, having a velocity roughly proportional to the mean declination of the sun in that month; the monthly inequalities being from north-eastward when the sun has south declination, and from south-westward when the sun has north declination; thus showing, unmistakably, a very decided connection between the position of the sun and the winds that blow at Kurrachee;—a connection which, when explained, leaves only a few minor details of the annual variation to be dealt with. Among these, may be mentioned the slight deflection of the wind to the south-eastward in the month of July, as compared with the preceding and following months. In the annual variation wind curve of Bombay, there is, in the first half of June, a similar but much more strongly marked deflection to the south-eastward, which immediately precedes the commencement of the strong south-west monsoon current. Whether the deflection, pointed out as existing at Kurrachee, bears any analogy to the similar movement at Bombay, or whether it is merely an irregularity which would disappear by the combination of a longer series of observations, cannot at present be determined. Another peculiar feature of the annual variation curve, having an important bearing on theoretical speculations as to the causes of the Indian monsoons, is, that the winds of March change into those of April, May, and June by the successive accessions of wind from the direction S43°W., and the wind of August into that of September by an increment exactly in the opposite direction, while the winds of September change into those of October, November, and December, by successive increments of wind from a direction more easterly, from about N60°E., and those of December into those of January, February, and March by successive increments in nearly the opposite direction, *viz.*, S63°W. The curve has thus a broken-backed appearance at the points for March and September; the axis of the figure lying in the direction S46°W. to N43°E. in the summer months, and in the direction S62°W. to N62°E. in the winter months. At Bombay also, as at Kurrachee, when the summer monsoon wind begins to slacken, a similar change of direction is apparent; the annual variation curve showing at first a progression in the direction N52°E., and afterwards in a direction more easterly, *viz.*, about N65°E. It is not impossible that (even at the same station, and regardless of deflections that may be produced by those local influences which have a limited sphere of action), the direction of variation of the great convection currents which constitute the monsoons is different in successive months; although the curve appears to indicate that during several months in each half-year that direction is invariable. It will presently appear, however, that the peculiarities referred to, as well as some others, are really due to influences which have a more limited sphere of action than those which produce the monsoons. If lines be drawn upon a map in the direction of the yearly resultant winds at Kurrachee and Bombay, so as to pass through those stations, and other lines in the directions of the annual variation of the wind between the summer and winter half-years at each of those places, it will be found that the former lines are directed more towards the middle of the Indian Peninsula than the latter lines, which have

decidedly a more northerly tendency. This fact appears to indicate that the yearly resultant winds are more directly dependent on local circumstances than the annual variation, and suggests that a clear comprehension of the character and causes of the monsoons would be greatly facilitated by a separation of the monthly resultant winds into their equivalent components, the annual resultant and monthly inequalities; and by a separate examination of the variations of each of these components with geographical position. The annual resultant wind at Kurrachee may perhaps be regarded as forming part of a permanent convection current blowing towards the southern portion of the Rajputana desert, and may be attributed to the average excess of the temperature of that region over that of the northern portion of the Arabian Sea. But the annual variation of the wind appears mainly to belong to the grander system of alternating convection currents, which blow from the Indian Ocean to Southern Asia in the summer, and in the contrary direction in the winter. That it is not, however, wholly of this character is apparent from the peculiarities that have been pointed out, and this will be rendered still more evident by the comparison which will presently be made of the annual variation of the wind with that of the barometer. We may expect, too, if the annual resultant wind can be regarded as belonging to a convection current of comparatively local origin, that it will have an annual variation of its own, depending, in form, on local variations of temperature, and modifying that which is due to more general causes.

There is, as might be expected, a close connection between the annual variations of the wind and barometric pressure, as will be seen from figures 77, 78, and 79, the first of which represents the barometric variation, as given in table XXV, the second that of the north components of the wind, and the third that of the east components. In each case the curve is one having a single maximum and a single minimum and approximating to a curve of sines, with the maximum in December and the minimum in or about July. Each curve also shows a comparatively slow fall and rapid rise.

It has already been pointed out that the annual variation of the wind largely depends on the declination of the sun; but figure 77 shows that the annual variation of the barometer is still more intimately dependent thereon. The closeness of this relation is best seen by the aid of Bessel's formula. When put into this form, the annual variations of the barometric pressure, north and east components of the wind, are respectively expressed by—

$$\begin{aligned}
\Delta B &= \cdot 133 \sin(\theta + 99^\circ 32') + \cdot 017 \sin(2\theta + 249^\circ 26') \\
&\quad + \cdot 010 \sin(3\theta + 173^\circ 32') + \cdot 010 \sin(4\theta + 346^\circ 48') + \&c. \\
\Delta N &= 3\cdot 56 \sin(\theta + 102^\circ 29') + 0\cdot 40 \sin(2\theta + 165^\circ 37') \\
&\quad + 0\cdot 38 \sin(3\theta + 100^\circ 43') + 0\cdot 24 \sin(4\theta + 260^\circ 8') + \&c. \\
\Delta E &= 5\cdot 20 \sin(\theta + 111^\circ 56') + 1\cdot 31 \sin(2\theta + 152^\circ 39') \\
&\quad + 0\cdot 09 \sin(3\theta + 12^\circ 32') + 0\cdot 31 \sin(4\theta + 3^\circ 41') + \&c.
\end{aligned}$$

in which the monthly inequalities of the several phenomena are assumed to correspond to equidistant intervals of time, and the angle θ is reckoned from the middle of January, at the rate of 30 degrees per month. From the first of these expressions, it appears that the co-efficient of the first periodical term is the only one of importance, being from eight to thirteen times as large as the co-efficients of the subsequent periodical terms. Simi-

larly the first co-efficient in the second expression is at least nine times as great as any of the succeeding ones; and in the third expression it is four times as great. The portions of the variations expressed by the first terms of these expressions, form then, by far the most important parts of the whole variations, and we should be justified in attributing these portions directly to the effects of the sun's varying declination, provided the epochs of their similar phases (as indicated by the constant angles within the brackets) were also in accordance therewith: but when we come to examine these features of the phenomena, we are met by the following anomalous result, *viz.*, the maximum phase of the barometric variation occurs on the 6th January, that of the north component of the wind on the 4th January, two days *earlier*, and that of the east component on the 24th December, or no less than thirteen days *earlier* than that of the barometric pressure. Thus although the phases of the barometric movement are in accordance with what might be expected, occurring, as they do, about sixteen days after the corresponding phases of the sun's declination, yet those of the wind, occurring *before* those of the barometer, appear to indicate that the winds occupy, as a link in the chain of causation, an intermediate position, and that they are consequently not the result, but the cause of the barometric variations. But such a conclusion, especially with reference to the great convection currents of the atmosphere, is so much at variance with received views on the nature of convection currents generally, as to throw grave doubt upon the propriety of drawing any except the most guarded conclusions from the co-efficients derived by the application of Bessel's formula to complex meteorological variations; and it seems far more probable that the anomalous results, pointed out, arise from the disturbing influence of local winds, which have no *proportionate* counterpart in the annual variation of pressure. To gain a clue to the nature of this disturbing influence, the following method has been adopted :—

Representing by B_w, B_s, N_w, N_s, E_w, E_s, the winter and summer means of the barometric pressure, north and east components of the wind respectively, the ratios

$\frac{N_w - N_s}{B_w - B_s}$ and $\frac{E_w - E_s}{B_w - B_s}$ have been taken, and the monthly barometric inequalities have then been multiplied by each of these ratios; the resulting variations have then been subtracted from the observed variations of the north and east components and the two series of differences given below obtained :—

TABLE X.

Residual annual variation of the North and East Components of the Wind at Kurrachee.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North components	+1·1	+0·6	−1·5	−1·9	−0·1	+1·4	+0·5	−0·9	+1·2	−0·8	−0·8	+1·9
East components ...	+0·9	−0·3	−5·6	−5·2	−1·0	+2·6	+1·5	−0·7	0·0	+0·9	+1·3	+3·3

It is clear that if the law of variation of the wind components had been exactly similar to that of the barometric pressure, these resulting differences would all have become zero, and that the values obtained show the extent of the deviation of the former laws from the latter. Figures 82 and 83 represent these deviations for the north and east components respectively. In both cases it will be seen that there is a minimum in March or April, and a maximum in December, the former occurring at the time when

the excess of the temperature of the land over that of the sea is greatest, the latter when the temperature of the interior is relatively coldest. There is also evidence of another maximum during the summer monsoon months, when the cooling influence of the clouds and rain is greatest, followed by another minimum which probably corresponds in time with the rise of temperature generally experienced in India immediately after the cessation of the summer rains. The validity of these remarks is shown by the following numbers and by figure 84, which exhibits the variation obtained by treating the monthly differences of temperature at Kurrachee and Hyderabad in the manner already described, using the Kurrachee barometric inequalities.

TABLE XI.

Mean monthly excess of Temperature at Kurrachee above that at Hyderabad.[1]

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
—1·4	—3·5	—7·0	—6·7	—8·5	—6·5	—5·3	—6·6	—4·4	—5·5	—1·2	+0·3

TABLE XII.

Residual annual variation of Temperature (Kurrachee minus Hyderabad).

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+1·1	—0 6	—3·1	—2·1	—2·6	+1·0	+2·5	—0·1	+1·4	—1·4	+1·5	+2·5

It thus appears that the annual wind variation at Kurrachee is divisible into two portions, the first and most important being a variation along a line in the direction N57°E, having a range of about 27 miles, and following the barometric law; the second, a variation along a line in the direction N72°E,[2] having a range of 9 miles, and following an annual law of progression similar to that which obtains in the differences of temperature between the coast and the interior. In obtaining these variations, the first has been supposed to vary along a line having a fixed direction, *viz.*, N57°E $= \tan^{-1}\left(\frac{E_w - E_s}{N_w - N^s}\right)$; and the second is seen, from the general similarity of the two figures 82 and 83, or by plotting the corresponding numbers in rectangular co-ordinates, to vary with moderate steadiness along a line in the direction N72° E. $= \frac{1}{2}\tan^{-1}\frac{2\Sigma(\Delta N . \Delta E)}{\Sigma(\Delta N)^2_{-}(\Delta E)^2}$ in which ΔN and ΔE represent the monthly inequalities of the residual variations of the north and east components respectively.[3]

It now becomes a question of interest to enquire whether similar results are obtainable from the corresponding data of other stations in India; for, if so, we shall then be in a position to draw somewhat extensive inferences as to the comparative efficiency of the *local* as distinguished from the more *general* causes which produce the Indian monsoons.

[1] *Vide* Meteorology of the Bombay Presidency, Table 146, page 184.
[2] *i.e.*, exactly the direction of the annual resultant wind.
[3] *Vide* Meteorology of the Bombay Presidency, page 114.

The following tables contain similar data for the stations Bombay and Calcutta :—

TABLE XIII.

Annual variations of the Components of the Wind at Bombay.[1]

(VELOCITY IN MILES PER HOUR.)

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North components	+5·8	+5·3	+4·2	+2·4	−1·6	−9·3	− 8·5	−5·3	−2·5	+2·4	+3·2	+3·9
East components...	+4·9	+3·2	+0·9	−0·4	−1·7	−3·8	−11·3	−9·0	−1·4	+4·8	+7·6	+6·4

TABLE XIV.

Annual variations of the Components of the Wind at Calcutta.[2]

(VELOCITY IN MILES PER HOUR.)

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North components	+2·08	+1·58	−1·30	−4·15	−3·50	−2·45	−1·10	+0·09	−0·21	+2·70	+3·28	+3·13
East components ...	−0·43	−0·89	−1·54	−0·96	−1·56	+0·83	+1·11	+1·74	+1·29	+0·89	−0·14	−0·26

Performing upon these numbers the operations already described, the following residual wind variations result, after the elimination, in each case, of the portion which follows the barometric law of variation at Bombay[3] and Calcutta[4] respectively.

TABLE XV.

Residual annual variations of the Wind Components at Bombay.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North components	−0·33	+0·61	+1·69	+2·98	+1·01	−1·72	−0·87	−0·66	−0·66	+1·43	−1·15	−2·19
East components...	−1·95	−2·03	−1·90	+0·25	+1·21	+4·67	−2·78	−3·82	+0·65	+3·72	+2·75	−0·10

TABLE XVI.

Residual annual variations of the Wind Components at Calcutta.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North components	−0·63	−0·36	−2·16	−3·72	−2·02	+0·18	+1·96	+2·32	+0·96	+2·11	+0·95	+0·19
East components ...	+0·13	−0·49	−1·37	−1·05	−1·88	+2	+0·48	+1·33	+0·95	+1·02	+0·34	+0·77

These variations are curved in figures 85 and 86 for Bombay, and for Calcutta in figures 88 and 89 ; and for comparison with them the temperature differences between Bombay[5] and Sholapur,[5] Calcutta[6] and Goalpara,[6] are given below, along with the residual

[1] *Vide* Meteorology of the Bombay Presidency, page [illegible].
[2] *Vide* Indian Meteorological Memoirs, Vol. I. Part I, page [illegible].
[3] *Vide* Meteorology of the Bombay Presidency, Table [illegible], page [illegible].
[4] *Vide* Indian Meteorologist's Vade Mecum, Part II. Table II, page [illegible].
[5] *Vide* Meteorology of the Bombay Presidency, Table [illegible], page 184.
[6] *Vide* Indian Meteorologist's Vade Mecum, Part II, page 176.

variations obtained after treating the numbers as before, using the Bombay and Calcutta barometric variations respectively. These residual variations are curved in figures 87 and 90:—

TABLE XVII.

Mean monthly excess of Temperature at Sholapur above that at Bombay.

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+0·9	+3·8	+6·4	+7·7	+4·4	—0·1	0·0	+0·9	+0·4	—0·9	—1·9	—4·0

TABLE XVIII.

Mean monthly excess of Temperature at Goalpara above that at Calcutta.

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
—4·9	—5·3	—6·9	—7·4	—7·9	—5·2	—2·4	—1·6	—2·7	—2·7	—3·7	—3·1

TABLE XIX.

Residual annual variation of Temperature differences (Sholapur minus Bombay).

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+0·6	+3·2	+5·5	+6·2	+2·5	—2·9	—2·8	—1·3	—1·3	—2·1	—2·5	—4·3

TABLE XX.

Residual annual variation of Temperature differences (Goalpara minus Calcutta).

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
—0·5	—0·9	—2·4	—2·9	—3·4	—0·6	+2·2	+3·0	+1·8	+1·7	+0·7	+1·3

From figure 85 we see that the residual variation of the north components of the wind at Bombay is, compared with that at Kurrachee (figure 82), reversed in character, thereby implying that the local centre of relatively great temperature disturbance, towards or from which these winds may be supposed to blow, are distinct, the one lying to the northward of Kurrachee, the other to the southward of Bombay. The almost exact similarity of form of figures 85 and 87, the latter of which is derived from the temperature differences between Bombay and Sholapur, is particularly noteworthy. The form of the residual east component variation at Bombay, figure 86, is, however, very different from that at Kurrachee, figure 83, implying that the local disturbing influences which operate upon the east components of the wind at Bombay are not the same as at

Kurrachee; or, what is more probable, that there are other causes of local disturbance at Bombay, which do not operate at Kurrachee. These are probably to be found in the violent squalls of wind from the eastward which occur very frequently at Bombay at the commencement and end of the monsoon, *viz.*, in June and October; the months in which figure 86 shows very decided maxima. These squalls, coming from the hills to the eastward, appear to be local disturbances of exactly the same kind as the storms in Bengal described by Mr. Eliot in Vol. I of these memoirs, pages 119 to 145.

At Calcutta the form of the residual variations of the north and east components, figures 88 and 89, is different. The curves have but one minimum and one maximum, the former occurring about April, and the latter, not in December, as at Kurrachee, but about the middle of the summer monsoon. They are, however, similar to each other, and also similar to figure 90, which has been obtained from the differences of temperature between Calcutta and Goalpara.

From these results we may infer that the annual variation of the wind at Bombay is considerably influenced by local differences of temperature, and that the annual variation of the wind at Calcutta, like that at Kurrachee, is divisible into two portions; the first being a variation along a line in the direction N12°W having a range of six miles, and depending on the annual variation of the barometric pressure; the second a variation, also with a range of six miles, along a line in the direction N26°E and depending on local differences of temperature. I do not, of course, assert that the particular residual variations of wind and of temperature differences that have been worked out, are the necessary counterparts of each other, but merely that there is *some* definite connection between these phenomena, the true character of which can only be discovered by an extensive comparison of the similar data of numerous stations. Nor do I overlook the fact that the temperature differences between Calcutta and Goalpara are such as favour, in accordance with the convection theory, winds in directions the reverse of those indicated; but the inference to be drawn from this is, that, in the hot months, a region of relatively high temperature occupies a position between the two stations; and if so, the residual wind variations at Goalpara would be reversed in direction as compared with those at Calcutta. The monthly charts accompanying the Report on the Meteorology of India in 1875 seem to support these views.

There must also, of course, be corresponding residual barometric variations, but these, in comparison with the portion of the annual variation which follows the simple sine law, are doubtless very small, though not theoretically unimportant. As an example, I take the following differences of pressure between Bombay and Poona from Mr. Charles Chambers's work on the Meteorology of the Bombay Presidency, page 280. They are the residual differences, found after allowing for difference of elevation, and eliminating the mean yearly difference of pressure:—

TABLE XXI.

Annual variation of the excess of Barometric Pressure at Bombay above that at Poona.

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
−·021	−·008	+·006	+·020	+·033	+·011	−·006	+·004	+·006	−·007	−·022	−·028

Eliminating from this variation the portion which follows the law of the annual barometric variation of the lower station, the following residual variation is obtained:—

TABLE XXII.

Residual annual variation of Barometric Pressure (Bombay minus Poona).

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December
—·003	+·006	+·013	+·018	+·025	—·011	—·028	—·009	+·001	—·001	—·009	—·010

It is graphically represented by figure 91, which will be seen to bear a close resemblance in one or more particulars to several of the curves Nos. 82 to 90. To investigate this subject further is beyond the scope of the present memoir, but enough has already been advanced to prove the existence of several local systems of convection currents, superimposed upon the grand general system which constitutes the winter and summer monsoons. They are evidently most active in the hottest weather, and disappear on the setting in of the rains. The smallness of the barometric variations which accompany them shows how limited is their sphere of action; and consequently, they probably play a very insignificant part in the production of rain. But the extent to which they mask the true character of the rain-bearing monsoon currents is very considerable; as may be inferred from the following ranges, which have been drawn out to show the comparative strength of the winds which are due to local circumstances, as distinguished from those which depend on more general causes:—

TABLE XXIII.

	Kurrachee.			Bombay.			Calcutta.		
	N.	E.	R.	N.	E.	R.	N.	E.	R
Range of residual variation, maximum-minimum $= a$ ...	3·8	10·1	...	5·2	8·5	...	6·0	3·2	...
Range of residual variation, April to July $= b$ ...	2·4	9 7	9·9	3·9	3·0	4·9	5·7	1·5	5·9
Range (December to July) of portion of annual variation which obeys the barometric law of variation $= c$ ...	14·7	22·2	26·6	13·7	15·3	20 5	6·1	1·3	6·2
Ratios $\frac{a}{c}$	2·58	·455	...	·379	·555	...	·983	2·462	...
Ratios $\frac{b}{c}$	...	...	·372	...	...	·239	...	...	·952

The ranges in the first line of the above table are simply the differences between the maximum and minimum values of the respective residual variations. Those in the third line are the barometric ranges of the several stations multiplied by the ratios used in calculating the residual wind variations. From these numbers we may infer

that absolutely, the local causes of wind are, (allowing for the excessive friction of the Calcutta wind instrument,) about equally efficient at the three stations; though their relative efficiency, and consequently their effect in masking the true character of the monsoon winds, is greatest at Calcutta and least at Kurrachee. Indeed, at Calcutta there appears to be as much wind produced by local as by general causes.

The resultant ranges above given, of those portions of the annual wind variations which obey the barometric law of annual variation, *viz.*, 26·6, 20·5, and 6·2 at Kurrachee, Bombay, and Calcutta respectively, afford perhaps the best measure we possess of the activity of the true monsoon currents at the respective stations, and they show how insignificant the monsoon currents of Bengal are when compared with those of Western India. This is a point of some consequence in the formation of the theory of the monsoons, for it implies either that the summer monsoon winds in Bengal have approached *much nearer to their final goal than* those of Western India, or that their motion has already been checked by the obstruction which the Himalayas offer to their onward progress, or perhaps that both of these conclusions are partially correct. Another probable inference from these facts appears to be, that the summer rainfall of by far the greater portion of India is drawn from the Arabian Sea, rather than from the Bay of Bengal, a conclusion which shows the importance of a much more exhaustive development of the meteorology of that sea, than appears to have yet been attempted.

The annual variation of the velocity of the wind (regardless of direction) is represented by figure 81, and the temperature variation,[1] for comparison, by figure 80. There is similarity in the form of these two curves, but a general connection of this simple kind, *i.e., one in which the movement increases with an increase of temperature,* is far from being a physical necessity, as affecting either the annual or diurnal variations. Indeed, in Western Europe generally, and at such stations as Mauritius and Ascension, in the heart of the south-east trade wind, the velocity of the wind appears to be less in the warm than in the cold months of the year; and at Kurrachee and Bombay the velocity is often less about noon than for some hours before and after that time.

To form some idea of the comparative persistence of the character of the annual variation in different years, the coefficients of the first four periodical terms of Bessel's formula have been calculated, from the monthly mean values of the north and east components for each year, in the manner already described. The results are given in the following table :—

TABLE XXIV.

		U'	u'	U''	u''	U'''	u'''	U''''	u''''
North components.	1873	3·77	104°54'	0·51	216°12	0·50	105°9'	0·49	303°22'
	1874	3·47	107°46'	0·36	109°26'	0·42	117°11'	0·49	167°5'
	1875	3·49	94°36'	0·69	156°48'	0·28	67°4'	0·41	282°41'

[1] Copied from "Meteorology of the Bombay Presidency," page 184.

East components.		U′	u′	U″	u″	U‴	u‴	U⁗	u⁗
	1873	5·25	114°4′	1·63	174°43′	0 13	171°15′	0·75	320°25′
	1874	4·93	110°14′	1·71	139°2′	0·40	71°7′	0·90	87°27′
	1875	5·41	111°21′	0·78	138°7′	0·44	307°39′	0·47	312°26′

From this table it will be seen that, for the north components, the values of the coefficients of the first periodical terms are remarkably steady in different years, the least value being 3·47 in 1874 and the greatest 3·77 in 1873. The corresponding angles indicate that the minimum phase of the first periodical term occurred in 1874 about the 27th of June, and in 1875 about the 10th of July, implying that, as compared with those of 1874, the north and south components of the monsoon winds of 1875 were delayed about thirteen days. The minimum phase of the same term for the east components, on the contrary, occurred in each year with remarkable regularity within two days of the 23rd June, and the magnitude of its coefficient in different years deviated less than ·3 from its mean value 5·20. The coefficient U″ of the second term for the east components, unlike that of the north components, has a considerable value, being on the average one-fourth as large as the coefficient U′. The maximum phases of the second term occur, on the average, about the 14th June and 14th December, but there is a maximum difference of about eighteen days, in the time of their occurrence in the different years. The U‴ coefficients of both north and east components are irregular in different years, and the corresponding angles u‴ indicate no uniformity in the epochs of similar phases, and therefore they probably represent no persistent part of the annual variation. It may be noticed, however, that the U⁗ coefficients, both of the north and east components, retain roughly the same magnitude in different years, and that the corresponding angles u⁗ do not differ much in the year 1873 and 1875, but that in 1874 they are in the opposite semi-circle. This may possibly arise from the influence of a real wind periodicity having a period somewhat greater or less than three months, and compared with a period of three months, losing or gaining a complete period in about two years, that is, a period of about a hundred or of about eighty days.

Comparison of the monthly abnormal variations of the Wind with those of Barometric Pressure.

TABLE XXV.

Mean monthly Barometric Pressure at Kurrachee.

Years.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1873	...	29·950	29·936	29·830	29 701	29 611	29·411	29·371	29·528	29·591	29 773	29 962	29·988
1874	...	30 008	29 948	29·809	29·796	29 623	29·496	29·474	29·564	29 662	29·802	29·956	30 014
1875	...	29·950	29·909	29·836	29·775	29·632	29·487	29·471	29·590	29·666	29·847	29·945	30·005
Mean	...	29·969	29 931	29 825	29·757	29·622	29 465	29·439	29·561	29·640	29·807	29·954	30·002
Variation	...	+·221	+·183	+·077	+·009	—·126	—·283	—·309	—·187	—·108	+·059	+·206	+·254

TABLE XXVI.

Mean monthly abnormal Barometric Pressure at Kurrachee.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1873 ...	−·019	+·005	+·005	−·056	−·011	−·054	−·068	−·033	−·049	−·031	+·008	−·014
1874 ...	+·039	+·017	−·016	+·039	+·001	+·031	+·035	+·003	+·022	−·005	+·002	+·012
1875 ...	−·019	−·022	+·011	+·018	+·010	+·022	+·032	+·029	+·026	+·040	−·009	+·003

TABLE XXVII.

Mean monthly North Components of the Wind at Kurrachee.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1873 ...	+3·6	+1·4	−2·8	−5·3	−6·0	−10·4	−13·3	−8·4	−5·0	−1·9	+2·9	+4·4
1874 ...	+4·6	0·0	−2·7	−5·8	−9·1	− 9·8	−9·8	−9·0	−3·8	−2·6	−0·2	+4·7
1875 ...	+1·3	+3·6	−4·2	−5·2	−6·2	− 9·0	−10·8	−11·2	−7·0	−4·5	0·0	+5·2
Mean ...	+3·2	+1·7	−3·2	−5·4	−7·1	− 9·7	−11·3	−9·5	−5·3	−3·0	+0·9	+4·8

TABLE XXVIII.

Mean monthly abnormal North Components of the Wind at Kurrachee.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1873 ...	+0·4	−0·3	+0·4	+0·1	+1·0	−0·7	−2·0	+1·1	+0·3	+1·1	+2·0	−0·4
1874 ...	+1·4	−1·7	+0·5	−0·4	−2·0	−0·1	+1·5	+0·5	+1·5	+0·4	−1·1	−0·1
1875 ...	−1·9	+1·9	−1·0	+0·2	+0·9	+0·7	+0·5	−1·7	−1·7	−1·5	−0·9	+0·4

TABLE XXIX.

Mean monthly East Components of the Wind at Kurrachee.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1873	−3·7	−6·5	−14·8	−16·8	−16·5	−19·8	−22·6	−18·3	−17·2	−8·2	−0·2	+2·2
1874	+3·3	−5·8	−13·9	−15·0	−16·5	−18·4	−15·7	−19·9	−15·2	−7·7	−3·4	+1·4
1875	−1·6	−0·8	−12·9	−16·6	−18·9	−21·5	−18·6	−20·0	−14·4	−8·5	−2·2	+2·5
Mean	−1·7	−4·4	−13·9	−16·1	−17·3	−19·9	−19·0	−19·4	−15·6	−8·1	−1·9	+2·0

TABLE XXX.

Mean monthly abnormal East Components of the Wind at Kurrachee.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1873	−2·0	−2·1	−0·9	−0·7	+0·8	+0·1	−3·6	+1·1	−1·6	−0·1	+1·7	+0·2
1874	+5·0	−1·4	0·0	+1·1	+0·8	+1·5	+3·3	−0·5	+0·4	+0·4	−1·5	−0·6
1875	−2·0	+3·6	+1·0	−0·5	−1·6	−1·6	+0·4	−0·6	+1·2	−0·4	−0·3	+0·5

To examine whether any relation exists between some of the abnormal or so-called non-periodic variations of the wind and barometric pressure, the following procedure has been adopted. From the individual mean monthly values of each of the three elements, barometric pressure, north and east components of the wind for the years 1873 to 1875, collected above, the annual variation has been approximately eliminated by subtracting the corresponding average values for the three years from the individual monthly values, thus leaving for each element the three series of thirty-six differences, also given in the above table. These differences may be taken to indicate fairly well the extent to which the values of each element deviated in each month from those of an ordinary season. The differences of each successive pair of these numbers were then taken for each element, giving a new series of thirty-five numbers, which, having regard to their proper algebraical signs, showed the rise or fall, increase or decrease, of each abnormal element from month to month. In the barometric series the minus signs were then altered into plus signs, and the signs (whether plus or minus) of the corresponding numbers of the two wind series were also changed, leaving the signs of those numbers which correspond to the originally positive barometric numbers unaltered. The algebraic sum of each series was then taken giving the following results:—

TABLE XXXI.

	Barometric Pressure.	North Components.	East Components.
Sums ...	+ ·816	+ 20·2	+ 29·5

from which it appears that an abnormal rise of a tenth of an inch of the barometer is accompanied by an abnormal increase in the velocity of the north component of the wind *of 2·5 miles per hour, and an abnormal increase in the velocity of the east component* of 3·6 miles per hour, or, in other words, when the barometer rises abnormally a tenth of an inch, it is accompanied by an abnormal wind from the direction N. 55° E, having a velocity of 4·4 miles per hour.

In the next table a similar comparison of the barometric pressure and the wind in the summer and winter half-years is made.

TABLE XXXII.

1873 to 1875.	Barometric Pressure.	North Component of Wind.	East Component of Wind.
Means, April to September ...	29·580	—8·0	—17·9
Means, October to March ...	29·915	+0 7	— 4·6
Differences ...	·335	+8·7	+13·3

These results show that a rise of the barometer from summer to winter of a tenth of an inch is accompanied by an *increase in the velocity of the north component of the* wind of 2·6 miles, and of the east component of 4·0 miles per hour, or by an increase in the velocity of the wind of 4·7 miles per hour from the direction N. 57° E. Comparing this result with that obtained above from the abnormal variations of the wind and

barometric pressure, it will be seen that they are very nearly alike, both showing that an increase of the wind velocity of nearly the same amount and from nearly the same direction accompanies the same change in the barometric pressure. The conclusion to be drawn from the similarity of these results is obvious, *viz.*, that the causes which produce the abnormal variations of the wind and barometric pressure are the same as, or similar to, those which produce the annual variations.

Now, the annual variations are known to be primarily dependent upon the gradually varying amount of the solar heat radiated upon different parts of the earth's surface as the sun annually changes his position in declination, and it is only on the supposition that the absolute amount of heat radiated by the sun in a given time is constant, that the annual variations of different years can be expected to be alike. If, however, the sun's heat is itself subject to fluctuations, either periodical or irregular, corresponding meteorological effects, similar to those which are produced by the sun's change of position, must result. The relation above pointed out between the abnormal variations of the wind and barometric pressure at Kurrachee appears to be one of the kind that would be anticipated on the supposition of the sun's heat being variable, and in itself affords a reason for suspecting, if it does not tend to prove, such variability.

It should be explained that the barometric observations used in the foregoing comparison were made daily at 9-30 A.M. and 3-30 P.M. with a mercurial mountain barometer by Newman, having a tube of narrow bore and a closed cistern, and that the vacuum of the instrument was far from perfect. Prolonged comparisons of the instrument (which was carefully left undisturbed) with a good barometer, were made from February to June 1876 at pressures differing widely, and from these it has been possible to determine corrections, which, when applied, give results that compare well with observations made at Deesa and Bombay, and which, I believe, are worthy of confidence.

Diurnal Variations.

Before proceeding to the study of the character of the diurnal variations of the wind at Kurrachee, and to their comparison with the variations of other places, it is desirable to call to mind the several causes which are at work producing diurnal variations of the wind, and also to consider what are the forms of the variations that may be expected from general principles to result from the operation of those causes. First, then, since all convection currents are due to differences of temperature, or more strictly speaking to differences of density of contiguous columns of air, which differences are either directly or indirectly referable to the sun's action, and since the sun's action on any portion of the earth's surface is never constant, but variable in intensity at different hours of the day, and altogether shut off between sunset and sunrise, it is to be expected that all the convection currents of the earth's atmosphere will be subject to corresponding diurnal variations of strength, and in some cases, even to a reversal of their direction. As to the forms of these variations, they will doubtless be intimately connected with those of the diurnal variations of temperature. I pointed out, some years ago,[1] that the curve showing the diurnal variation of the velocity of the land-and-sea breezes at Bombay has nearly the same form as the

[1] Philosophical Transactions 1873, Vol. 163, pages 1—18.

curve of the diurnal variation of air temperature, and it is prbable that, generally, the form of the temperature variation is also approximately that of the land-and-sea-breeze variation, when unaffected by other disturbing influences: if, indeed, it is not the common form of the variations of *all* pure convection currents which depend on temperature differences only; for such a form would be that which these convection current variations would necessarily tend to assume, if the friction which opposes the motion were proportional to the velocity, and this is the assumption usually made. If, however, the radiant heat of the sun is largely expended in the production of vapour, and only in a minor degree in heating the atmosphere, as is the case over the open ocean, the variations of atmospheric density will depend to a considerable extent on the rate of evaporation, and the law of the diurnal variation of the convection currents may then be considerably modified. Such, at least, appears to be the case with the diurnal variation of the trade wind at Mauritius, and some of the diurnal variations of the wind during the summer monsoon in India, which variations, as will hereafter appear, follow a law more nearly approximating to that of the diurnal variation of the solar radiation than to that of air temperature. We may, therefore, expect to find at least as many different kinds of diurnal wind variations as there are varieties of convection currents. These may be divided into two great classes, general and local: the first comprising the diurnal variations of the trades and anti-trades, and all convection currents that depend on the latitude; the second, those of the monsoons, land-and-sea breezes, and all convection currents that are due to the relative distribution of land and water, the varying contour of the land, or differences in the character of contiguous portions of its surface; whether covered by snow and ice, thick forests, luxuriant or scanty herbage, or altogether devoid of vegetation.

One of these latter cases, *viz.*, that in which a portion of the surface is covered with snow and ice, while a contiguous portion is free from it, seems to be worthy of special notice. In this case, the solar heat radiated upon the former portion will be chiefly expended in melting the snow and ice, while that which falls upon the uncovered surface will be spent in heating the soil and the air above it. Consequently, convection currents should blow more strongly in the daytime than during the night, from the former region to the latter.

But besides these various systems of convection currents, producing winds which at the earth's surface always blow *from* the comparatively cool region *towards* the place of relatively high temperature, there exist, as observation has now most distinctly proved, certain systems of diurnal wind variations of quite a different character,—winds which, in the relatively hot hours of the day, blow *outwards* from regions of relatively high temperature, from which, as from a centre, they appear to radiate towards the comparatively cool regions around. These outward movements during the daytime appear to be succeeded by return inward movements during the night, accompanied by atmospheric oscillations, which vary in period with the extent of surface affected by them, and which may, perhaps, roughly be compared with the oscillatory movements of water in a bath, after the level has been abruptly disturbed, or to the *seiches* or non-tidal periodical oscillations, which have been observed in the Swiss lakes and certain portions of the sea.

These outward movements of air in the daytime from centres of relatively high temperature might appropriately be called *anti-convection currents.* Their causes are

at present but imperfectly understood; indeed, the observational facts concerning them are as yet very meagre, and it is one of the objects of the present paper to add to this store of facts. So far as they go, however, they appear to indicate that these systems of anti-convection currents, like the pure convection currents, may be divided into two great classes, general and local. The first of these classes I have already attempted to define in a paper on the "Diurnal Variations of the Wind and Barometric Pressure at Bombay," published in the "Philosophical Transactions" for 1873, pages 1 to 18. From a consideration of the facts therein advanced, I deduced what I supposed would be the general form of this class of wind currents, and have since had the satisfaction to find those views well borne out by subsequent results.[1] Except for high latitudes, this system of wind movements may be approximately described as follows:—Imagine the surface of the globe divided into quadrants by the meridian lines of 4, 10, 16, and 22 hours of civil time, and that very gentle winds are blowing *outwards* in all directions from the middle of that quadrant over which the sun is vertical, *inwards*, towards the middle of each of the two adjoining quadrants, and *outwards* from the middle of the opposite quadrant. Such a system of winds, revolving daily about the earth with the sun, and acting independently and alone on the wind vane, would cause it to make two right-handed rotations in the twenty-four hours in the northern hemisphere, and two left-handed rotations in the same time in the southern hemisphere. Or, if the north and east components of these wind variations be viewed separately, we should find that the curve, showing the variation with time of the east component, would be similar in character in both hemispheres, and also similar to the curve of diurnal variation of barometric pressure in having maximum values about 10 A.M. and P.M., and minimum values about 4 A.M. and P.M. On the other hand, the variation of the north component would be found to be opposite in character in the two hemispheres, having maximum values in the northern hemisphere about 7 A.M. and P.M., and minimum values about 1 A.M. and P.M.; while in the southern hemisphere the maximum values of the north component would occur at 1 A.M. and P.M., and the minimum values about 7 A.M. and P.M. It is this system of atmospheric movements, which, in all probability, produces the more salient features of the diurnal variation of the barometric pressure.[2] My reasons for this view, as well as graphic representations of the wind variations described, will be found in the papers already quoted.

Our knowledge of the second or local class of diurnal wind movements from centres of relatively high temperature is even more scanty than that of the more general system above described. Indeed, beyond the fact that, during the day hours, hot winds do blow outward from the middle of highly heated and extensive tracts of land such as India, Australia, North Africa, &c., we know almost nothing. It does appear probable, however, from the evidence that will appear in the sequel, that these wind variations are divisible into two subordinate classes, which depend upon different actions of the same cause, the solar radiation, and are distinguishable by the forms of the curves representing their variations with time. The first of these subordinate classes is probably dependent, in the manner pointed out by Sir John Herschell, upon the inequality of the height to which the strata of equal density are elevated, by the unequal

[1] *Vide* a supplementary paper on "The Diurnal Variations of the Winds and Barometric Pressure" published in the Proceedings of the Royal Society, Vol. XXV, pages 402—411.

[2] For the view here expressed, more especially, Mr. Chambers is alone responsible.—H.F.B.

heating of different portions of the earth's surface by solar radiation; the second, in some manner not yet well understood, upon differences in the *rate* of increase of the air temperature.

If, then, all these varieties of diurnal variations of the wind are possible, it is to be expected that the actual variation observed at any particular place, except under unusually favourable circumstances, will be of a very complex character; for it will be the resultant variation produced by the combined action of all the individual variations, each of which will tend to mask the true character of the others; and the problem that lies before us is how to separate the resultant variation into its individual elemental component variations. The satisfactory accomplishment of this separation is a necessary preliminary to the discovery of the causes which produce all the elementary variations, and therefore to the possibility of any complete explanation being given of the complex observed variation.

The method of separation, usually employed, is that afforded by the application of Bessel's formula. By means of this process, the original complex variation is artificially divided into separate portions, each of which obeys the simple sine law of variation, but differs from the rest in its period of variation, the first portion going through a complete cycle of changes *once* in twenty-four hours, the second *twice*, the third *three times*, and so on. It does not of necessity follow, however, that each of these variations has any independent physical existence, and can therefore be ascribed to some independent cause. Indeed, it is easy to see that these component variations, although of simple form, may be due to a variety of causes, and therefore may still be regarded as complex variations. The coefficients of Bessel's formula are, however, often very suggestive, and I shall therefore first examine the diurnal variations from this point of view.

The adoption of other simple methods of analysis, bearing as close an analogy as possible to those employed in experimental physical investigations, is, however, frequently advantageous. In the investigation of natural phenomena which are fit subjects for experimental enquiry, and in which the observed effects are due to a variety of conditions, the method of experiment usually adopted is to vary one of the conditions, and only one, at a time, keeping all the rest as nearly as possible constant, and to observe the change of effect produced by the variation of this one condition; then to proceed to vary a second condition which is known or suspected to affect the result, while the condition formerly varied and all the remaining conditions are kept constant; then to note the resulting variations of effect, and so on. In this manner, the separate effects due to the variation of each one of the conditions become known, and thus a knowledge is acquired of the causes of the complex effect, produced by the variation of many of the conditions at the same time. In meteorological enquiries the subjects of investigation are generally very complex phenomena which cannot be subjected to experimental variation; but it is often possible, by a judicious selection of observations, to choose for comparison certain results, which vary *chiefly* from the preponderating influence of the variation of but one condition, while the rest, though generally not altogether invariable, change so slightly as to produce but a small effect on the result. The difference of effect observed under such circumstances, may, often with much assurance, be attributed mainly to the variation of the one condition which is known to undergo considerable alteration. I shall freely employ this method in the sequel, in analysing the complex variations into simpler component variations, wherever it may apparently be used with profit.

The following tables[1] contain the calculated coefficients of Bessel's formula:—

TABLE XXXIII.

North Components of the Wind in miles per hour.

Months.	U' sin. u'.	U' cos. u'.	U'' sin. u''.	U'' cos. u''.	U''' sin. u'''.	U''' cos. u'''.	U'''' sin. U''''.	U'''' cos. u''''.
January	+1·72	+5·27	+0·01	−1·30	−0·07	+0·79	+0·09	−0·04
February	+2·79	+4·92	−0·47	−1·19	+0·22	+0·72	−0·20	+0·07
March	+3·27	+4·39	−0·80	−0·93	+0·76	+0·05	−0·30	+0·21
April	+3·12	+4·22	−0·59	−0·53	+0·56	−02·4	−0·05	+0·13
May	+3·07	+2·98	−0·54	−0·94	−0·06	−0·23	−0·06	+0·22
June	+1·39	+4·34	+0·06	−1·09	+0·14	−0·12	+0·12	+0·07
July	+0·63	+2·25	+0·34	−0·90	−0·03	−0·15	+0·15	−0·17
August	+0·92	+2·65	+0·28	−0·76	+0·11	−0·10	+0·13	+0·01
September	+1·59	+2·86	−0·43	−0·57	+0·02	−0·15	+0·13	+0·11
October	+3·41	+4·58	−0·70	−1·64	+0·59	−0·01	−0·23	+0·06
November	+4·08	+5·27	−1·18	−1·72	+0·77	+0·56	−0·18	−0·04
December	+2·16	+4·60	−0·26	−1·42	+0·24	+0·61	−0·03	+0·04
Year	+2·35	+4·03	−0·36	−1·08	+0·27	+0·14	−0·04	+0·06

East Components of the Wind in miles per hour.

Months.	U' sin. u'.	U' cos. u'.	U'' sin. u''.	U'' cos. u'	U''' sin. u'''	U''' cos. u'''.	U'''' sin. u''''.	U'''' cos. u''''.
January	−0·79	+4·62	+1·11	−1·13	−0·41	+0·15	+0·06	+0·08
February	−0·35	+5·79	+0.64	−1·52	−0·24	+0·22	−0·03	−0·13
March	+1·24	+4·06	−0·46	−1·49	+0·11	+0·32	+0·09	+0·04
April	+1·20	+3·30	−0·27	−1·67	+0·21	−0·17	+0·18	−0·06
May	+1·81	+1·79	−0·27	−1·25	−0·31	−0·22	−0·23	−0·02
June	+0·80	+0·73	−0·09	−0·54	−0·05	0·00	+0·15	+0·09
July	+0·59	−0·38	+0·23	−0·65	−0·14	−0·14	0·00	+0·08
August	+0·45	−0·30	−0·18	−0·66	−0·48	−0·15	+0·07	+0·03
September	+1·99	−0·11	−0·95	−0·60	−0·30	+0·04	+0·01	+0·19
October	+2·35	+4·85	−0·29	−1·65	−0·17	−0·28	−0·01	+0·17
November	+0·07	+5·31	+0·81	−1·92	−0·35	−0·21	+0·10	+0·53
December	−0·72	+3·78	+0·98	−1·52	−0·67	0·00	+0·13	+0·19
Year	+0·72	+2·79	+0·10	−1·22	−0·23	−0·04	+0·05	+0·10

[1] In these tables and throughout this paper the correcting factors $\frac{\left(\frac{\pi}{n}\right)}{\operatorname{Sin}\left(\frac{\pi}{n}\right)}$, $\frac{\left(\frac{2\pi}{n}\right)}{\operatorname{Sin}\left(\frac{2\pi}{n}\right)}$, $\frac{\left(\frac{3\pi}{n}\right)}{\operatorname{Sin}\left(\frac{3\pi}{n}\right)}$, &c., to the 1st, 2nd, 3rd, &c., harmonical terms have not been applied; neither has the further correcting factor $\frac{\operatorname{Sin}\left(\frac{\pi}{m}\right)}{\left(\frac{\pi}{m}\right)}$ which is applicable to each term on the supposition that the wind directions are uniformly distributed throughout the arc under which they are classed.

In these factors n is the number of intervals into which the full period of a day or a year is divided, and throughout which the mean values are taken; and m is the number of parts into which the circle is divided in tabulating the wind directions.

TABLE XXXIV

North Components of the Wind.

Months.	U'	u'	U''	u''	U'''	u'''	U''''	u''''
January	5·55	18° 5'	1·30	179° 34'	0·79	354° 56'	0·10	113° 58'
February	5·65	29° 33'	1·28	201° 33'	0·76	16° 59'	0·21	289° 17'
March	5·48	36° 41'	1·23	220° 42'	0·76	86° 14'	0·37	305° 0'
April	5·25	35° 29'	0·79	229° 4'	0·61	113° 12'	0·14	338° 58'
May	4·28	46° 51'	1·08	209° 53'	0·24	194° 37'	0·23	314° 45'
June	4·56	17° 45'	1·09	176° 51'	0 18	130° 36'	0·14	59° 41'
July	2·34	15° 38'	0·96	159° 18'	0·15	191° 19'	0 23	138° 35'
August	2·80	19° 8'	0 81	159° 47'	0·15	132° 17'	0 13	85° 36
September	3·27	29° 5'	0·71	217° 2'	0·15	172° 24'	0·17	49° 46'
October	5·71	36° 40'	1·78	203° 7'	0·59	91° 3'	0·21	284° 9'
November	6·67	37° 45'	2·09	214° 26'	0·95	53° 58'	0·19	257° 28'
December	5·08	25° 9	1·44	190° 23'	0·65	21° 28'	0 05	323° 8'
Year	4·66	30° 15'	1·14	198° 27'	0·30	62° 36'	0·07	326° 18'

East Components of the Wind.

Months.	U'	u'	U''	u''	U'''	u'''	U''''	u''''
January	4·69	350° 17'	1·58	135° 31'	0·44	290° 6'	0·10	36° 52'
February	5·80	356° 33'	1·65	157° 10'	0·33	312° 31'	0·13	167° 0'
March	4·25	16° 59'	1·56	197° 9'	0·34	18° 58'	0·10	66° 4'
April	3·51	19° 59'	1·69	189° 11'	0·27	128° 59'	0·19	108° 25'
May	2·55	45° 19'	1 28	192° 12'	0·38	234° 38'	0·23	265° 2'
June	1·08	47° 37'	0·5	189° 28'	0·05	270° 0'	0·18	59° 3'
July	0·70	122° 47'	0·69	160° 31'	0·14	225° 0'	0 08	360° 0'
August	0·54	123° 41'	0·68	195° 15'	0·50	252° 39'	0·08	66° 48'
September	1·99	93° 10'	1·12	237° 43'	0·30	277° 35'	0·19	3° 1'
October	5·39	25° 51'	1·68	189° 58'	0·33	211° 16'	0·18	346° 46'
November	5·31	0° 45'	2·08	157° 7'	0·41	239° 2'	0·54	10° 41'
December	3·85	349° 13'	1·81	147° 11'	0·67	270° 0'	0·23	34° 23'
Year	2·88	14° 28'	1·20	175° 14'	0·20	260° 5'	0·11	26° 34'

The monthly coefficients given in the above tables are graphically represented by figures 92 to 97,[1] in which the corresponding values of U sin. u and U cos. u for each month are combined, positive values of U sin. u being marked off upward, and positive values of U cos. u to the right. An imaginary line drawn from the centre of any

[1] These figures are constructed in the same manner as those given in Plate XXI of the "Meteorology of the Bombay Presidency," with which they may be compared.

figure to any one of its monthly points, shows, by its length, the value of U for that month, and by the angle which its direction makes with the upward line, the time at which the maximum phase of that particular component variation occurs, the time being reckoned from midnight at the rate of 15° per hour for U′, 30° per hour for U″, 45° per hour for U‴, and so on.

An inspection of these diagrams shows that each of the component variations changes very considerably during the year, both as regards amplitude and phase; most of them presenting very decided annual and semi-annual variations of the values of U and u.

A small portion of the variation of the values of the u's, is of course due to the varying value of the equation of time; but the greater part of the variations of the values of both U's, and u's from month to month, is evidently attributable more or less to local circumstances; such as variations in the strength of the land-and-sea breezes, and the hot winds from the interior. The character of these disturbing influences will be best seen hereafter, by the adoption of a different method of investigation. The variations from month to month of the coefficients of the first and second periodical terms of the formula for the north components are, on the whole, similar; the values of U′ and U″ and of u′ and u″ increasing and decreasing simultaneously, thereby indicating that they are due to the variations of one and the same cause, and that, except artificially, they may not be regarded as independent variations. A similar remark is applicable, but with less force, in the case of the variations of the corresponding coefficients of the formula for the east components. There is, however, one remarkable feature in the variation of the second periodical term for the east components, which is specially worthy of notice, for it appears to indicate that at least a portion of this term is due to a different cause from that which produces the first periodical term. It is this; that while the value of U′ diminishes in July and August to less than one-fourth of its mean value for the year, and is earlier in phase by more than seven hours, the value of U″ in the same months, is more than half its mean value for the year, and is almost identical in phase. This appears to imply that there is an independent residual semi-diurnal variation of the east component of the wind, having a range of about one and a half miles, and a maximum easterly value a little after 9 hours A.M. and P.M., and a minimum easterly or maximum westerly value a little after 3 hours A.M. and P.M., corresponding very closely in phase with the second periodical term of the variation of the barometric pressure. That this is really the case, will be seen hereafter from a different method of exhibiting the same results.

The values of U‴ for the north components are sensibly steady, and have a considerable magnitude from October to April, but they are small from May to September. So long as they retain considerable values, they have a very systematic variation of phase, as shown by the corresponding values of u‴.

There is a considerable degree of similarity, probably not altogether accidental, in the annual variation of the values of U‴ cos. u‴ for the north components of the wind at Kurrachee and of the corresponding values for the barometric pressure at Bombay[1] and Calcutta.[1] These variations probably depend mainly on the varying length of the day.

[1] *Vide* values of b_3 of Table 87 of page 118 of the "Meteorology of the Bombay Presidency" and of U‴ cos. u‴ of Table II, page 173, of Vol. I of "Indian Meteorological Memoirs."

The U'''' and u'''' coefficients of both north and east components of the wind at Kurrachee are very small and irregular, and the curves for these are therefore not given.

We will now proceed to examine the diurnal variations of the wind as represented by figures 1 to 16. One of the most striking features is the general similarity of the elongated form of the variation in the different months. In almost all cases, the night hours, viewed from the middle of each figure, occupy the north-east quadrant, and the day hours the south-west quadrant; and in all the months from October to May the rotation is right-handed, but from June to September left-handed. From October to May, the longer axes of the figures lie between north-east and north-north-east, but from June to September they are much more northerly. The range of the variation varies from 19 miles in November to only $5\frac{1}{2}$ miles in July, but from October to April it is never less than 14 miles. The diurnal variation curve is widest in November, when the hour points from 7 hours to 14 hours lie on the east side of the major axis of the figure, and those from 16 hours to 5 hours on the west side. From this month onward, the sides gradually close in until they pass each other in May or June, and thereby change the direction of rotation from right-handed to left-handed, and place the hours about noon on the west side of the figure, while those of the evening occupy the east side. From June onward, the sides of the figures continue to separate, until the month of September; and then comes a comparatively abrupt change in the reverse direction; the sides of the figure re-passing each other between the middle of September and the middle of October, thereby reproducing the right-handed direction of rotation. They then rapidly widen out again until the form of the November curve is re-attained.

Another important characteristic is, that while the direction of the mean resultant wind veers from west-south-west in October to north-north-east in December, and backs through the same angle between December and April, the longer axis of the diurnal variation curve maintains, during all those months, an almost *invariable direction* between north-east and north-north-east; or, in other words, when the mean daily resultant wind is from the north-east, the hourly resultant winds are stronger in the night than during the day; but when its direction is from south-west, they are strongest in the day-time and weakest at night.

Another remarkable feature, highly interesting from its connection with the diurnal variation of the barometric pressure, and well brought out in the mean curves for the year, and for each half-year, is the presence of two east and west oscillatory movements of the wind in the twenty-four hours, corresponding approximately in phase with the semi-diurnal oscillations of the barometric pressure. Any similar semi-diurnal oscillatory movement that may exist in a north and south direction is completely masked by being mixed up with the very extensive north and south movement of a different kind.

Before proceeding to enquire into the causes of these various features of the diurnal wind variations, we will first examine the curves delineated in Plate XVII, figures 16 to 45, which show the variations in equal increments of time of the north and east components of the wind separately. The north component curves are, on the whole, similar in form, throughout the year; the changes from month to month being mainly variations of range only, which is relatively small in the summer and large in the winter. The mean curve for the year, figure 30, is very remarkably like an inverted temperature variation curve, but later in phase by about half an hour. One noteworthy peculiarity is, that in the

months about the equinoxes, the minimum occurs considerably earlier than in those about the solstices, whereas the time of maximum seems to depend more definitely on the time of sunrise. Most of the east component curves, figures 31 to 45, have also some resemblance to inverted temperature curves, but, unlike the north component curves, they show very considerable alterations of form from month to month, as well as variations of range. Indeed, the curves for the monsoon months, July to September, appear to be of quite a different type from those for the remaining months of the year, and the lateness of the morning maximum from December to February, as compared with October, March, and April, constitutes a modification of form which is of too great a magnitude to be attributed to the lateness of sunrise merely, neither does the relative lateness of the afternoon minimum in the former months appear to be attributable to a mere change in the length of the day.

There can be little doubt that the greater part of the variation of the north component of the wind is due to the land-and-sea breezes. The fact that the form of the mean curve for the year approaches very nearly to that of a temperature curve, is sufficient proof that this is the case; but further evidence to the same effect is afforded by a comparison of the ranges of the diurnal variations of the temperature, and those of the north component of the wind. The next table shows for each of these elements the range in each month and the mean range for the year, the ranges being derived in the case of the wind by taking the differences between the mean values for 7 and 15 hours, and in the case of the temperature by taking corresponding differences between the temperatures at 6 and 14 hours, these latter being obtained from table 104, page 143, of the "Meteorology of the Bombay Presidency."

TABLE XXXV.

Monthly ranges of the North and East Components of the Wind and of Air Temperature at Kurrachee.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
North components .	12·00	11·53	11·17	9·00	8·90	9·23	4·66	5·77	6·67	11·83	13·90	11·17	9·72
East " .	8·00	11·07	10·27	8·80	5·10	2·57	0·43	0·00	2·06	11·91	12·63	7·70	6·79
Temperature .	19·8	20·8	15·9	13·7	9·6	8·0	5·8	7·1	8·9	21·9	24·6	21·2	14·8

From this table it will be seen that the maximum ranges of the wind and temperature variations both occur in the month of November, and that the minimum ranges also happen simultaneously in July. The ordinary theory of the land-and-sea breezes suffices, therefore, to explain the more salient features of the variation of the north component of the wind at Kurrachee.

We will now turn our attention to the causes of the variations of the east components of the wind. It has already been remarked that most of the east component curves, figures 31 to 45, have some resemblance to inverted temperature curves. To the extent to which this is the case, they doubtless represent true convection currents which are mainly to be attributed to the difference in the range of temperature of the air over the sea surface, and of that over the land surface to the eastward, that is, over the northern portion of the delta of the Indus. This district, unlike the hilly country to

the northward, becomes flooded in the summer by the inundation of the river, and thus the temperature variation of the air over this region will be reduced in range to nearly the same as that of the air over the sea. The land-and-sea breezes in this direction will therefore become nearly obliterated in the inundation season, while those which blow to and fro between the sea and the hills to the northward, where the range of temperature is unaffected by the inundation, will only be somewhat weakened by reason of the prevailing cloudiness of that season—a conclusion which is well borne out by the observations.

It will be noticed, however, that the maximum, the minimum, and the zero values of figure 43, occur later than the corresponding phases of figure 44, and looking at the curves for each individual month, it will be seen that this feature, the lateness of the phases, is most marked in the months November to February, and that it afterwards disappears. The same fact is indicated, perhaps more forcibly, by a reference to figures 95 and 96, in which the points for the months November to February are abruptly dislocated from those for October, March, and April. The theory of the land-and-sea breezes is incapable of explaining these peculiarities, for we know that the variations of temperature which produce those breezes do not alter in phase in this manner. We must therefore look elsewhere for light upon them. Now, figures 40 to 42 and 31 to 34 show that the diurnal variations of the east components from October to April may be divided into two distinct classes, those for the months October, March, and April forming one class, those for November to February another; and since the idea of mere change of phase of the land-and-sea breezes does not appear to satisfactorily explain the difference between these two classes, we may try whether the notion of the existence of a distinct and independent variation in the months November to Februray, superimposed on the variation of the land-and-sea breezes, will afford any clue to the meaning of the change in the character of the mean variation in these two sets of months. The form of this superimposed variation may be inferred from figures 95 and 96, but it will be more clearly exhibited by taking the differences between the mean hourly values of the east components of the wind for the two sets of months. This is done in the following table:—

TABLE. XXXVI.

Mean East Components of the diurnal Wind variation.

Hours.	Midnight.	1	2	3	4	5	6	7	8	9	10	11
Mean of October, March, and April	+1·57	+1·63	+1·77	+2·20	+2·67	+3·67	+4·67	+4·73	+4·37	+3·07	+1·93	−0·07
„ of November to February	+0·10	+0·85	+1·30	+1·75	+2·50	+3·37	+4·02	+4·85	+4·80	+4·72	+4·80	+3·62
Differences	−1·47	−0·78	−0·47	−0·45	−0·17	−0·30	−0·65	+0·12	+0·43	+1·65	+2·87	+3·69
Hours.	**Noon.**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Mean of October, March, and April	−2·07	−3·47	−5·20	−5·60	−5·37	−4·80	−3·97	−2·60	−1·00	−0·13	−0·13	+0·67
„ of November to February	+1·55	−0·45	−2·70	−5·00	−6·35	−6·40	−5·75	−4·45	−2·62	−2·27	−1·40	−0·47
Differences	+3·62	+3·02	+2·50	+0·60	−0·98	−1·60	−1·78	−1·85	−1·62	−2·14	−1·27	−1·14

The above differences are curved in figure 98, which appears to imply that in the months November to February, there exists, superimposed upon the variation due to the land-and-sea breezes, an independent variation of quite a different character; the salient features of which are, that soon after sunrise, the wind begins to blow from the eastward, increases in strength till about noon, and then gradually grows weaker till about sunset, when it is succeeded by a gentle return current from the opposite direction. There can, I think, be no doubt, that this is the local system of anti-convection currents or hot land winds already described, and it is worthy of note that at Kurrachee they appear to blow with considerable force only so long as the resultant wind of the twenty-four hours is not decidedly from seaward, as may be seen by a reference to figure 76.

We are now prepared to understand some of the peculiarities of figures 92 and 93, in which it will be noticed that the points for the months December, January, and February, compared with the points for October, March, and April, are dislocated as in figures 95 and 96; that is, downward in the case of figure 92, as in figure 95, upward in the case of figure 93, as in figure 96. These features appear to be attributable to the local system of anti-convection currents, and to imply that those winds blow to and fro along lines lying almost due east in November, about east-north-east in December and February, and about north-east in January.

If we now refer to figures 144, 145, 148, and 149 of Plate XXI of the "Meteorology of the Bombay Presidency," we shall find that in the months of November and December, when the resultant wind of those months at Bombay is from landward, there are similar dislocations of the points for November and December, as compared with the points for October, March, and April. I think it highly probable that these dislocations are also due to the hot land winds or *local* anti-convection currents; a view which is confirmed by an inspection of the Bombay vapour pressure curves for November and December given in the same work, for it will be seen that figures 474 and 475, Plate XLI, show very decided depressions about noon, indicating an excessive dryness of the air, which may fairly be attributed to the hot winds of those months. If this be admitted, the dislocations referred to of the wind curves at Bombay, imply that at that station the hot winds blow from the south-eastward. It is clear, however, that these winds form but a small and comparatively unimportant feature of the Bombay wind system.

Results comparable with those represented by figures 92 to 97 are not yet available for any other station in India except Bombay; so that we cannot proceed further with this rigid method of comparison, but the form of the curve representing the local anti-convection currents at Calcuttā and Belgaum may be obtained with tolerable accuracy for the former station, and roughly for the latter, by combining the observations for those months in which the local anti-convection currents form the most prominent feature of the wind variation. With this object in view, I have in the first place, in order to obtain tolerably smooth flowing curves, grouped, for each quarter of the year, the north and east components of the wind at Calcutta, taking the data from Table C, page 30, Vol. I of the "Indian Meteorological Memoirs." These results are given below and curved in figures 99 to 106.

TABLE XXXVII.

Mean Hourly North and East Components of the Diurnal Wind Variation at Calcutta in each quarter of the year.

(Velocity in miles per hour.)

		Mid-night to 1.	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to noon	Noon to 13.	13 to 14	14 to 15.	15 to 16.	16 to 17	17 to 18.	18 to 19	19 to 20	20 to 21.	21 to 22	22 to 23.	23 to Mid-night	Mean.
January to March.	North ...	−0.20	−0.02	+0.31	+0.16	+0.48	+0.65	+0.73	+0.57	+0.52	+0.08	+0.59	+0.63	+0.77	+0.61	+0.34	+0.09	−0.30	−0.74	−1.03	−1.21	−1.15	−1.15	−0.98	−0.66	−0.78
	East ...	+0.25	+0.35	+0.30	+0.34	+0.52	+0.51	+0.41	+0.38	+0.19	+0.16	−0.04	−0.25	−1.05	−1.20	−1.14	−1.03	−0.34	+0.22	+0.30	+0.20	+0.23	+0.18	+0.08	+0.08	−0.79
April to June.	North .	+0.08	+1.26	+1.47	+1.63	+1.83	+1.90	+1.18	+0.11	−0.56	−0.71	−0.71	−0.48	−0.64	−1.01	−1.19	−1.72	−1.83	−1.10	−1.02	−0.58	−0.10	+0.16	+0.48	+0.71	−4.04
	East ...	+0.62	+0.51	+0.58	+0.56	+0.57	+0.73	+0.32	−0.40	−1.04	−1.26	−1.68	−1.10	−0.85	−0.97	−0.90	−0.41	−0.09	+0.19	+0.09	+0.58	+0.63	+0.90	+0.76	+0.88	−0.40
July to September	North .	+0.53	+0.07	+0.80	+0.95	+0.90	+0.86	+0.76	+0.15	+0.16	+0.04	0.00	−0.03	−0.78	−0.91	−1.15	−1.36	−1.23	−0.66	−0.16	−0.33	−0.03	+0.05	+0.23	+0.39	−1.07
	East ..	−0.40	−0.46	−0.45	−0.52	−0.50	−0.28	+0.05	+0.45	+0.46	+0.58	+0.65	+0.51	+0.23	+0.10	+0.18	+0.37	+0.09	−0.26	−0.25	−0.45	−0.24	−0.16	−0.12	−0.26	+1.52
October to December.	North .	−0.57	−0.51	−0.40	−0.32	−0.38	−0.39	−0.25	+0.10	+0.63	+1.05	+1.28	+1.17	+1.26	+1.21	+1.13	+0.82	−0.01	−0.77	−0.05	−0.98	−0.07	−0.92	−0.85	−0.73	+1.49
	East .	−0.10	−0.10	−0.09	−0.09	−0.07	0.00	0.00	+0.02	+0.22	+0.25	+0.30	+0.29	+0.06	−0.26	−0.35	−0.13	0.00	+0.02	−0.06	−0.01	+0.04	+0.05	+0.02	−0.07	+0.33

For Belgaum I have placed all the available observations in three groups:—

1st.—Those for the cold months October to February.

2nd.—Those for the hot months March to May.

3rd.—Those for the wet monsoon months June to September.

These observations were recorded hourly on one day in each month, with some exceptions, from August 1875 to September 1877 and on three days in each month from February 1878 to November 1878 by means of a small Robinson's anemometer, not self-registering.[1] The velocity for any particular hour was found by taking the sum of half the differences of the readings of the anemometer at that hour and at the preceding and following hours, the corresponding direction observation being that observed at the middle hour. These results were then resolved into their north and east components, and the averages for each hour calculated.[2] They are given in the following table and curved in figures 107 to 112:—

TABLE XXXVIII.

Mean Hourly North and East Components of the Diurnal Wind Variation at Belgaum.

(Velocity in miles per hour.)

	Hours.	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid-night.	1	2	3	4	5	Means.	Number of days.
October to February.	North ...	+0·33	+0·19	−0·13	−0·54	−0·01	−0·20	+0·12	−0·09	−0·20	−0·50	+0·60	+0·41	+0·24	+0·19	+0·20	+0·28	+0·23	+0·01	−0·01	+0·06	+0·17	−0·23	−0·13	−0·06	−0·35	17
	East ...	−0·10	+0·97	+2·12	+3·62	+4·12	+3·10	+2·98	+3·30	+2·33	+0·69	−1·17	−1·40	−2·31	−2·80	−2·75	−2·07	−2·56	−1·82	−1·18	−1·14	−0·86	−0·61	−0·54	−1·10	+1·12	17
March to May.	North ..	+0·03	+0·59	+0·95	+0·62	+0·70	+2·13	+1·04	+1·35	−0·54	+0·16	−0·7	−0·03	−0·04	−0·04	−0·64	−0·74	−0·27	−0·37	−0·23	−0·35	−0·63	−0·53	−0·24	−0·13	+0·04	15
	East ...	+1·44	+1·44	+2·27	+3·18	+4·10	+1·05	+3·22	+2·30	0·00	−1·35	−3·32	−1·80	−5·04	−4·52	−3·60	−1·89	−1·37	−0·50	+0·37	+0·58	+0·79	+0·62	+0·75	+0·74	−2·85	15
June to September.	North ...	+0·21	+0·39	+0·37	+0·29	+0·13	−0·12	−0·25	+0·52	+0·14	−0·13	−0·13	−0·50	−0·21	−0·18	−0·07	−0·22	−0·31	−0·38	+0·36	+0·30	+0·02	−0·12	−0·17	−0·29	+0·13	21
	East ...	+1·84	+1·20	−0·07	−0·92	−1·47	−1·70	−2·13	−1·79	−2·19	−2·59	−3·00	−2·35	−1·92	−0·79	+0·29	+0·74	+1·15	+1·88	+2·03	+2·12	+1·89	+2·26	+3·00	+2·81	−0·65	21

[1] This instrument has not been compared with one of the large Robinson Beckley anemographs, but it may be mentioned that several small instruments of the same description have been compared with the Bombay anemograph, with the result that the mean velocities indicated by the small instruments require to be multiplied by factors varying from 1·30 to 1·10 to make them agree with that given by the large anemograph.

[2] No correction has been applied for the effects of friction.

From among figures 99 to 112, it is easy to select several of similar form to figure 98 which shows the character of the local anti-convection currents at Kurrachee. Of these, figures 102 and (when inverted) 104 for Calcutta, and figures 108 and 110 for Belgaum, may be mentioned, in all of which the common predominating features appear to be due to the local systems of anti-convection currents. The influence of these currents on the forms of most of the remaining curves is also very clearly traceable: indeed the peculiar forms of several of them appear to arise almost entirely from the conflicting influences of the local convection currents or land-and-sea breezes and the local systems of anti-convection currents. To show this in two cases, *viz.*, figures 99 and 111, both of which are, on the whole, similar in form, it is only necessary to subtract the ordinates of figure 102 from those of figure 99, and those of figure 110 from those of figure 111, when, in both cases, the form of the resulting difference curves will be found to be very approximately that of an inverted temperature curve, or of a pure coast convection current, which proves that figures 99 and 111 result mainly from the combined action of local convection currents following the temperature law of variation, and a system of local anti-convection currents following the law of variation approximately represented by figure 98.

In figures 100 and 101 the coast convection currents predominate, but the influence of the local anti-convection currents is still traceable in the upward deflection of the curves about noon. Figure 106 shows, by the downward deflection a little after noon, the incipient appearance of anti-convection currents from the westward. In figure 103 these are more decidedly developed: in figure 104 they are completely in the ascendant; and in figure 105 have almost entirely disappeared. Similarly, figures 109 and 112 show that, at Belgaum, the anti-convection currents cease to blow in the monsoon months June to September; while figures 107 and 110 show that they blow from somewhat south of east on the mean of the months October to February; and figures 108 and 111 indicate that they blow from considerably north of east from April to May; that is to say, the direction appears to vary with the varying position of a local centre of maximum range of temperature in the interior,[1] from which these winds seem to radiate.

We are thus furnished with another means of distinguishing these local systems of anti-convection currents, *viz.*, that while the coast convection currents, except under very unusual circumstances, appear to blow along a line having a constant inclination to the coast line, the local systems of anti-convection currents, on the contrary, vary in direction, and blow from the nearest local centre of maximum range of temperature, a centre which varies in position at different seasons of the year. So far as a judgment can be formed from available data, the anti-convection currents at Calcutta and Kurrachee appear to conform with this view.

Another means of distinguishing these currents from the pure convection currents is afforded by the forms of the curves of diurnal variation of vapour pressure. I have already noticed, in the diurnal vapour pressure curves for November and December at Bombay, one peculiarity, which appears to me to be due to these winds; and an inspection of the curves of Plate XLI of the "Meteorology of the Bombay Presidency" discloses many more, which are doubtless due to the same influence. Of these, we may notice the rapid change from a minimum about noon to a maximum about sunset in

[1] *Vide* Plates in the Reports on the "Meteorology of India" in 1875 and 1876.

the months March to April at Belgaum; a change which corresponds with the similar change of the wind as indicated by figure 111. There are similar movements in the vapour pressure curves for the same months at Poona, which probably imply a similar change of the wind at that station; but for direct evidence of this we must await the results to be derived from a self-recording anemometer recently erected there.

Before leaving the subject of local anti-convection currents, there is one more remarkable and significant feature common to figures 104, 105, and 110, which is worthy of special notice. This is, that each of the curves 105 and 110 has a principal maximum value at 10 hours, a secondary maximum about 13 hours, and an intermediate secondary minimum value at 12 hours, and that a similar remark is applicable to figure 104 by changing the word maximum to minimum and *vice versâ*. Mr. Blanford has already noticed a somewhat anomalous interruption in the curve of diurnal variation of wind velocity (without regard to direction) at Calcutta.[1] The mechanical component curves, above referred to, prove the interruption to be, beyond doubt, a real natural phenomenon, and give it great definiteness of character. It is clear, then, that any theory devised to completely explain the local systems of anti-convection currents must take account of this feature. Before attempting to frame such a theory with much probability of success, it is essential that the barometric variations which accompany and are related to the local anti-convection currents should be determined; but of these we yet know absolutely nothing. We are, therefore, not in a position to do much more than guess at the probable causes of the anti-convection currents. I would suggest, however, that the curves we are now discussing, *viz.*, figures 104, 105, and 110, result from the combination of two distinct variations, the first having a principal maximum about 10 hours, and depending, in some way not yet completely explained, on the *rate* of increase of air temperature; the second having a principal maximum about 13 hours, and depending, in the manner described by Sir John Herschel in his Meteorology, Article 77*a*, on the inclination produced in the atmospheric strata of equal density by reason of the unequal heating and consequent unequal expansion upwards of different portions of the atmosphere. Some foundation for believing this to be the case may be obtained by taking the differences of the ordinates of figures 103 and 104. This has been done below, and the difference curve is represented by figure 113, which, it will be seen, has a principal minimum at 10 hours, and shows that figure 104 may be viewed as resulting from the combination of two distinct variations like those represented by figures 103 and 113 :—

TABLE XXXIX.

Differences of the Ordinates of the Curves representing the East Components of the Winds at Calcutta in the first and second quarters of the year.

Midnight—1	1—2.	2—3.	3—4.	4—5.	5—6.	6—7.	7—8.	8—9.	9—10.	10—11.	11—noon.
+0·37	+0·16	+0·28	+0·22	+0·05	+0·22	—0·09	—0·78	—1·23	—1·42	—1·64	—0·85
Noon—1	13—14.	14—15.	15—16.	16—17.	17—18.	18—19.	19—20.	20—21.	21—22.	22—23.	23—Mid.
+0·20	+0·23	+0·24	+0·62	+0·25	—0·03	+0·33	+0·27	+0·40	+0·72	+0·68	+0·80

[1] *Vide* "Indian Meteorological Memoirs," Vol. I, pages 8 and 9.

On the foregoing supposition, the peculiar inflection about noon in all the figures 104, 105, and 110 would be accounted for merely as one result of the combined action of the two separate variations.

We must now return to the consideration of other features of the diurnal variations of the wind at Kurrachee. It has already been remarked that figures 33 to 40 show that the variations for the months October, March, and April form a class by themselves, in which the coast convection currents play the greatest part. On the other hand, we see from the same figures, that the variations for the months July and August form another class, in which the coast convection currents have almost died out; chiefly because in these months, the ground surface is screened by the monsoon clouds from direct solar radiation; and if this were the only cause of change in the character of the variation of these two classes of curves, we should expect that the curve of the differences of their ordinates would agree in form with an inverted temperature curve; any deviation therefrom being attributable to other causes. To gain some information as to how far the change of form is due to the mere disappearance of the coast convection currents, and how far to other causes, the differences given below have been taken and curved in figure 114, the north component differences being marked off upwards, the east component differences to the right, as in figures 1 to 15.

TABLE XL.

Mean North and East Components of the Diurnal Wind Variation at Kurrachee in the two sets of months (October, March, and April) and (July and August), with their differences.

Hours.		Midnight.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
North components.	October, March, and April = (S)	+3·1	+3·6	+3·9	+4·1	+4·3	+4·6	+4·9	+4·0	+4·4	+2·5	−0·4	−2·8
	July and August = (t) ...	+1·7	+1·3	+2·6	+1·4	+2·7	+2·8	+4·4	+3·0	+3·5	+2·5	+1·5	+0·6
	Differences (S—t) ...	+1·4	+2·3	+1·3	+2·7	+1·6	+1·8	+0·5	+1·0	+0·0	0·0	−1·9	−3·4
East components.	October, March, and April (S) ...	+1·6	+1·6	+1·8	+2·2	+2·7	+3·7	+4·7	+4·7	+4·4	+3·1	+1·9	−0·1
	July and August (t) ...	+0·5	−0·4	−0·4	−1·0	−0·1	−0·9	+0·1	−0·5	−0·3	−0·5	−0·4	−0·6
	Differences (S—t) ...	+1·1	+2·0	+2·2	+3·2	+2·8	+4·0	+4·6	+5·2	+4·7	+3·6	+2·3	+0·5
Hours.		Noon.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
North components.	October, March, and April (S) ...	−4·8	−5·8	−5·9	−6·1	−5·3	−4·8	−3·9	−2·9	−1·3	0·0	+1·4	+2·1
	July and August (t) ...	−0·3	−2·3	−3·6	−4·7	−4·7	−4·6	−3·6	−3·9	−1·6	−0·8	+0·6	+1·4
	Differences (S—t) ...	−4·5	−3·5	−2·3	−1·4	−0·6	−0·2	−0·3	+1·0	+0·3	+0·8	+0·8	+0·7
East components.	October, March, and April (S) ...	−2·1	−3·5	−5·2	−5·6	−5·4	−4·8	−4·0	−2·6	−1·0	−0·1	−0·1	+0·7
	July and August (t) ...	+0·1	−0·4	−1·2	−1·5	−0·9	−1·2	+0·7	+1·1	+2·2	+2·1	+2·4	+0·7
	Differences (S—t) ...	−2·2	−3·1	−4·0	−4·1	−4·5	−3·6	−4·7	−3·7	−3·2	−2·2	−2·5	0·0

Now, assuming that the pure land-and-sea breezes blow to and fro along a line having a fixed direction during the whole of a day, if the above hourly differences were wholly due to the mere cessation of the land-and-sea breezes in the monsoon months, the north and east component differences of corresponding hours would in all probability bear to each other a constant ratio; and therefore, when curved, as in figure 114, would give rise to a figure, in which the hourly points would lie approximately along a straight line,

the inclination of which would depend on the value of that ratio; but we see that figure 114 is very far from satisfying this condition, for the curve is a very open one, although, looking separately at the points from 7 to 12 hours, and from 18 hours to 1 hour, when the velocity of the land-and-sea breezes is changing most rapidly, they do approximately lie along straight lines which are nearly parallel to the longer axis of the figure. These latter features may therefore be accounted for mainly by the dying out of the land-and-sea breezes, but to explain the openness of the figure we must needs look elsewhere.

For this explanation we have not far to seek among the numerous possible systems of diurnal wind variations. The principal peculiarities of figure 114 remaining to be explained are, that the points for the hours before noon appear to lie too much to the eastward, those about noon too much to the southward, and those after noon too much to the westward. Now, since all systems of diurnal wind variations, whether they be classed as convection or anti-convection currents, whether they be regarded as general or local, depend either directly or indirectly on solar radiation, it seems reasonable to suppose that, in cloudy weather, when the solar radiation is received directly, not by the earth's surface, but by the canopy of clouds above, the range of variation of all classes of diurnal wind variations, observable on the earth's surface, will be reduced in the hours of the day. If so, not only will the coast convection currents tend to disappear in cloudy weather, but the range of the general system of anti-convection currents will also be reduced, and we ought to find evidence of this in figure 114. Such evidence, it appears to me, is what is afforded by the openness of that figure, and by the peculiarities in it which have been pointed out. It tends therefore to establish the existence at Kurrachee of the same system of general anti-convection currents to which I have elsewhere drawn attention as existing at Bombay, Bermuda, Falmouth, and other places.

The only important local peculiarity of the east component curves now remaining to be dealt with, is exhibited by the curve for September, figure 39. The character of this peculiarity may be seen by a reference to figures 95 and 96, in which it will be noticed that the points for the month of September are abruptly dislocated from those of the previous month, in an upward direction in the former figure, and downward in the latter. This means that the variation of August changes into that of September, by the addition of a variation very similar in form to that represented by figure 98, but *reversed* in direction; *i.e.*, a variation in which the wind is relatively quiescent during the night hours, begins to increase in velocity from the west soon after sunrise, attains its maximum velocity about noon, and then gradually becomes weaker until about sunset. Now, this is very unlike the simple reappearance of the coast convection current at the close of the summer monsoon, and though the curve is similar in form to the variation of the local system of anti-convection currents, it is nevertheless in the wrong direction to be attributed to them. Turning to figures 92 and 93, we see that there are somewhat similar dislocations of the points for September in the north component variations; which imply that, in this month, an additional variation is established, which causes the wind to be more southerly during the hours of the day, particularly about noon, than during the hours of the night. These facts seem to indicate a diurnal variation in the strength of the coast convection current; but before this view can be entertained, it is necessary to find reasons why the form of the variation is not, as would at first sight seem most probable, like that of the diurnal variation of air tem-

perature, but approximately like the curve of solar radiation. On this point we may gain some additional information by an examination of the form of the diurnal variation of the east-south-east trade wind at Mauritius. It appears from observations made and reduced at that station by Mr. Charles Meldrum, who has kindly furnished me with a copy of them, that the diurnal variation is most marked in the southern winter.

TABLE XLI.

Mean Diurnal Variation of the East Component of the Wind at Mauritius in the months April to September.

Hours	6	7	8	9	10	11	Noon.	13	14	15	16	17
East components ...	−2·69	−0·71	+2·74	+3·99	+5·71	+4·85	+5·19	+5·48	+3·83	+3·21	+1·48	−1·01
Hours.	18	19	20	21	22	23	Midnight.	1	2	3	4	5
East components ...	−1·80	−2·22	−2·21	−2·45	−2·53	−2·74	−2·85	−2·98	−3·06	−3·10	−3·13	−3·01

TABLE XLII.

Mean Diurnal Variation of the Temperature of the Air at Mauritius in the months April to September.

Hours.	6	7	8	9	10	11	Noon.	13	14	15	16	17
Temperature ...	−1·5	−1·4	−0·9	−0·2	+0·8	+1·3	+2·0	+2·2	+2·2	+2·2	+1·6	+0·8
Hours	18	19	20	21	22	23	Midnight.	1	2	3	4	5
Temperature ...	+0·1	−0·2	−0·5	−0·6	−0·8	−0·9	−1·1	−1·1	−1·1	−1·2	−1·2	−1·3

The mean variation of the east component of the wind at Mauritius in the months April to September is given above and curved in figure 115, which, though retaining some of the characteristics of a temperature curve (as will be seen by comparing it with figure 116 which represents the temperature variation at Mauritius in the same months) nevertheless approaches more nearly to the form of the variation of the intensity of the solar radiation. This peculiarity is, I believe, partly due to the superposition, on the diurnal variation of the trade wind, of the general system of diurnal anti-convection currents; but probably, chiefly to the fact that over the ocean the solar radiation is expended more in producing evaporation than in heating the air, and that consequently, the diurnal variation of the trade wind is not merely an effect of differences of temperature of contiguous portions of the atmosphere, but largely an effect of a difference of density due to differences in the rate at which contiguous portions of the atmosphere are being charged with vapour. If this be so, we may anticipate that whenever there is a considerable difference in the rate of evaporation from contiguous portions of the earth's

[1] *Vide* British Association Report for 1867, page 124.

surface, convection currents will blow towards the place where evaporation is greatest and give rise to a wind variation approaching in form to that represented by figure 115. Now, it is a well-known fact that evaporation is greater from a wet sandy soil than from the surface of water, until the soil is sufficiently dried to acquire a lighter colour than when wet. When, therefore, the inundation of the delta of the Indus subsides, as it does at the close of the monsoon, the soil of the flat delta, as soon as the monsoon clouds clear away, will be eminently in a condition to promote more rapid evaporation than over the sea, and this will give rise to a wind variation of the form which we have noticed as existing in the month of September at Kurrachee. As soon, however, as the soil becomes sufficiently dried, the usual coast convection current, producing a variation having the form of a temperature curve, should reappear, and this is what takes place in the following month, October.

Similarly, it is probable that rapid evaporation over the surface of India generally, during and about the close of the summer monsoon season, gives rise to weak though sensible currents blowing inward from the surrounding seas, thus producing wind variations of the same form as those just described. How much, then, of the peculiar variation of the east component of the wind at Kurrachee in the month of September, is due to evaporation over the surface of the delta merely, and how much to evaporation over the surface of the country generally, could only be determined by comparison with similar observations made elsewhere. I have looked for similar abrupt changes at the close of the summer monsoon in the character of the wind variations at Calcutta and Bombay, but without finding any very definite indications of them; consequently, the evidence, as far as it goes, seems to point to evaporation over the Indus delta as the chief source of the peculiarity of the September east component variation at Kurrachee.

The only east component curves which have now not been specially noticed, are those for May and June, and these, with regard to their main features, may be dismissed with the remark that they are intermediate in character between those for the months of April and July. The curves for April, May, and June are, however, very remarkable from another point of view, in that they afford decided evidence in favour of the existence at Kurrachee of that general system of anti-convection currents which was first brought to light by the Bombay wind observations,[1] and which I have already described. This will be rendered most apparent by adopting a method of analysis similar to that which was used in the case of the Bombay wind observations, the main object of which was to eliminate the coast convection currents. For this purpose it is advisable to choose certain months in which the local anti-convection currents do not blow, to avoid excessively cloudy months, in which we cannot expect that the variation of the general system of anti-convection currents in the day hours will be considerable, and also to avoid those months in which the variation of the east component appears to depend largely on the rate of evaporation over the delta. We shall then have to eliminate only the variations of the land-and-sea breezes in order to obtain the residual variation due to the general system of anti-convection currents. The months which appear most suitable for this purpose are April, May, and June. The mean north and east components of the wind variations for these months have

[1] Mr. Laughton had drawn attention to this class of winds in 1871. Phil. Mag., 4th Ser., Vol. XLI, p. 325.—H. F. B.

been taken, and in order to smooth off any slight irregularity which still remains, the means of each consecutive pair of ordinates have been twice taken. These results are given below and curved in figure 117 :—

TABLE XLIII.

Mean North and East Components of the Wind at Kurrachee in the months of April, May, and June.

Hours	Midnight	1	2	3	4	5	6	7	8	9	10	11
North component ...	+2·35	+2·77	+3·05	+3·37	+3·74	+4·08	+4·22	+4·01	+3·20	+1·70	—0·03	—1·62
East component ..	+1·08	+0·98	+0·80	+1·03	+1·44	+1·92	+2·31	+2·28	+1·93	+1·35	+0·64	—0·30
Hours.	**Noon**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
North component ...	—2·96	—3·97	—4·67	—4·99	—4·90	—4·51	—3·65	—2·41	—1·23	—0·18	+0·83	+1·69
East component ...	—1·44	—2·35	—2·93	—3·22	—3·15	—2·69	—1·88	—0·83	+0·07	+0·69	+1·00	+1·02

As before explained, if the wind variation in these months were wholly due to the coast convection currents, there is no apparent reason why the hourly points of figure 117 should not lie along a straight line, which we see is approximately the case; but we see also that there are bends to the eastward about 9 or 10 hours A.M. and P.M., and to the westward about 3 or 4 hours A.M. and P.M., and we have to enquire to what these deflections are due.

Indicating the hourly inequalities of the north and east components of the wind by N. and E. respectively, we may calculate the easterly or westerly deflection D of each hourly point by the formula :—

$$D = E - N \tan \alpha$$

in which α is the angle included between the north line and the line along which the coast convection currents blow; and if we suppose that the coast convection currents and the general system of anti-convection currents are the only wind variations that exist in these months, we shall have—

$$N = N_c + N_g$$
$$E = E_c + E_g$$

in which N_c and E_c are the north and east components of the coast convection currents, and N_g and E_g the components of the general system of anti-convection currents. From the assumption that the coast convection current is a variation along a straight line, we get—

$$E_c = N_c \tan \alpha$$

and we shall then have—

$$D = E_g - N_g \tan \alpha$$

which involves the components of the general system of anti-convection currents and a constant factor only.

The most satisfactory way of determining the angle α will perhaps be to calculate from the hourly inequalities of the north and east components, the direction of greatest variability in the manner proposed by Mr. Charles Chambers in Art. 146 of his "Meteorology of the Bombay Presidency." The value of α given by this method is 28° 17′, inserting which in the above formula we obtain the values of D given below, which are curved in figure 118. For comparison with them the values of E_g —N_g tan α for Bermuda are also given and curved in figure 119:—

TABLE XLIV.

Hourly values of E_g —N_g tan α at Kurrachee.

Midnight.	1	2	3	4	5	6	7	8	9	10	11
—0·18	—0·51	—0·84	—0·78	—0·57	—0·27	+0·04	+0·12	+0·21	+0·44	+0·66	+0·57
Noon.	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
+0·15	—0·21	—0·42	—0·54	—0·51	—0·26	+0·08	+0·47	+0·73	+0·79	+0·55	+0·11

TABLE XLV.

Hourly values of E_g —N_g tan α at Bermuda.

Midnight.	1	2	3	4	5	6	7	8	9	10	11
+0·62	+0·36	+0·01	—0·48	—0·88	—0·92	—0·82	—0·49	—0·28	0·00	+0·44	+0·31
Noon.	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
+0·17	—0·01	—0·26	—0·21	—0·33	—0·26	+0·02	+0·24	+0·43	+0·71	+0·88	+0·85

The general similarity of these two figures is so evident that it is almost impossible to draw any other conclusion than that the same causes which produce the peculiar wind variation observed at Bermuda, are in operation at Kurrachee also, in other words, that the wind movements indicated by the figures form part of a *general* system of diurnal wind variations, not of a merely local system.

Further evidence to the same effect is obtainable from a comparison of the wind variations at Kurrachee and Calcutta in July and August. In these months the local winds have less influence than in most of the remaining months of the year, on account of the general prevalence of cloud and rainfall. If, then, any general system of diurnal *anti-convection currents* exists, we may expect that (during the height of the summer monsoon) it will be less over-ridden and obscured by periodical local influences than at other times, and particularly will this be the case during the night hours, when the local winds are always comparatively less influential than during the day time.

The mean diurnal variations of the north and east components of the wind in July and August at Kurrachee and Calcutta are given in the following tables:—

TABLE XLVI.

Kurrachee.

Hours.	Midnight.	1	2	3	4	5	6	7	8	9	10	11
North components	+1·18	+0·86	+1·78	+0·96	+1·85	+1·91	+2·95	+2·05	+2·35	+1·70	+1·03	+0·41
East components	+0·38	—0·28	+0·16	—0·66	—0·08	—0·65	+0·06	—0·33	—0·23	—0·33	—0·28	—0·43
Hours.	Noon.	13	14	15	16	17	18	19	20	21	22	23
North components	—0·20	—1·53	—2·45	—3·16	—3·16	—3·06	—2·45	—2·61	-1·10	—0·57	+0·45	+0·93
East components	+0·11	—0·28	—0·85	—1·00	—0·61	—0·83	+0·46	+0·78	+1·50	+1·40	+1·60	+0·50

TABLE XLVII.

Calcutta.

Hours.	Midnight to 1.	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to noon.
North components	+0·41	+0·51	+0·70	+0·85	+0·82	+0·84	+0·82	+0·62	+0·39	+0·18	+0·08	—0·06
East components	—0·41	—0·48	—0·52	—0·54	—0·45	—0·31	+0·05	+0·44	+0·37	+0·53	+0·68	+0·51
Hours.	Noon to 13	13 to 14	14 to 15	15 to 16	16 to 17	17 to 18	18 to 19	19 to 20	20 to 21	21 to 22	22 to 23	23 to midnight.
North components	—0·60	—0·80	—1·11	—1·38	—1·32	—0·63	—0·53	—0·34	—0·02	+0·01	+0·17	+0·33
East components	+0·26	+0·51	+0·55	+0·36	+0·13	—0·28	—0·38	—0·52	—0·22	—0·13	0·00	—0·14

The data for Calcutta are obtained from Table C, page 30, Vol. I, of these Memoirs. The observations of both stations do not extend over a sufficient number of years, to enable the non-periodic irregularities to be perfectly eliminated by merely taking averages, and the mean hourly inequalities have therefore been smoothed by taking successively the means of each consecutive pair. This process has been performed only once upon the inequalities for Calcutta, twice upon those for Kurrachee, by which means the numbers are not only smoothed, but made to correspond in point of time. The smoothed

variations are given below, and represented graphically by figures 120 and 121, figure 121 having a scale twice as open as figure 120:—

TABLE XLVIII.

Kurrachee.

Hours.	Midnight.	1	2	3	4	5	6	7	8	9	10	11
North components	+1·03	+1·17	+1·34	+1·38	+1·64	+2·15	+2·46	+2·35	+2·11	+1·68	+1·04	+0·41
East components	+0·24	0·00	−0·15	−0·31	−0·36	−0·32	−0·21	−0·20	−0·28	−0·29	−0·32	−0·25
Hours.	**Noon.**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
North components	−0·38	−1·42	−2·39	−2·98	−3·13	−2·93	−2·64	−2·19	−1·34	−0·44	+0·31	+0·87
East components	−0·12	−0·32	−0·74	−0·86	−0·76	−0·45	+0·22	+0·88	+1·29	+1·47	+1·27	+0·74

TABLE XLIX.

Calcutta.

Hours.	Midnight.	1	2	3	4	5	6	7	8	9	10	11
North components	+0·37	+0·46	+0·60	+0·77	+0·83	+0·83	+0·83	+0·72	+0·50	+0·28	+0·13	+0·01
East components	−0·27	−0·44	−0·50	−0·53	−0·49	−0·38	−0·13	+0·24	+0·40	+0·45	+0·60	+0·59
Hours.	**Noon.**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
North components	−0·33	−0·70	−0·95	−1·24	−1·35	−0·97	−0·58	−0·43	−0·18	0·00	+0·09	+0·25
East components	+0·38	+0·38	+0·53	+0·45	+0·24	−0·07	−0·33	−0·45	−0·37	−0·17	−0·06	−0·07

A glance at these figures is sufficient to decidedly reveal the existence, during the night hours, of similar east and west wind movements on opposite sides of the Indian Peninsula, as well as movements in contrary directions during the hours of the day. There can be no doubt that the *contrary* east and west movements are of local origin, but it is difficult to imagine how the movements in the *same* direction on *opposite* sides of the Peninsula can be so regarded, and it seems far more probable that these are indications of the existence of that general system of anti-convection currents which appear to move synchronously with the regular diurnal variations of the barometric pressure. If the contrary local east and west movements on opposite sides of the Peninsula were of the same magnitude, they might easily be eliminated by simply taking the mean of the east component variations at the two stations, but we find by an inspection of the figures that the range of the Calcutta curve, figure 121, is only about half as great as that for Kurrachee, figure 120. This may be due partly to

the great friction of the Calcutta instrument, and partly to the fact that Calcutta is not, like Kurrachee, close to the sea, but some distance inland. As, however, the local peculiarities of figure 121, except as regards direction and range, appear to be similar to those of figure 120, by arbitrarily increasing the range of the former, until it approximates to that of the latter, we may roughly eliminate, as above described, the local peculiarities, and obtain an approximate view of the form of the general east and west wind variation. The east components of figure 121 have therefore been doubled, and the mean of these products and of the east components of figure 120 have then been taken, giving the numbers of the following table, which are graphically represented by figure 122:—

TABLE L.

Midnight.	1	2	3	4	5	6	7	8	9	10	11
—0·15	—0·44	—0·57	—0·68	—0·67	—0·54	—0·23	—0·04	—0·26	+0·30	+0·44	+0·46
Noon.	13	14	15	16	17	18	19	20	21	22	23
+0·32	+0·22	+0·16	+0·02	—0·14	—0·29	—0·22	—0·01	+0·27	+0·56	+0·57	+0·30

The form of this figure bears a strong resemblance to that representing the diurnal variation of the barometric pressure, and the times of the maxima and minima are nearly the same as in the barometric curve; thus affording independent evidence of the same kind as that which I have deduced from the Bombay wind observations, to the effect that the diurnal variation of the barometric pressure is accompanied, and probably partly caused, by a similar variation of the east components of the wind—a variation which is not due to merely local peculiarities, but to general causes, and observable wherever the diurnal barometric variation can be detected.

The character of the truly local peculiarities will be perhaps best exhibited, approximately free from the effects of the general wind movements, by taking half the difference of the two variations, the means of which have yielded the variation represented by figure 122. These hourly differences are given below and curved in figure 123; the meaning of which is that, during the height of the summer monsoon, the local convection currents which blow inwards toward the middle of the Peninsula are stronger in the day time than during the hours of the night:—

TABLE LI.

Midnight.	1	2	3	4	5	6	7	8	9	10	11
+0·39	+0·41	+0·42	+0·37	+0·31	+0·22	+0·02	—0·24	—0·54	—0·59	—0·76	—0·71
Noon.	13	14	15	16	17	18	19	20	21	22	23
—0·44	—0·51	—0·90	—0·88	—0·62	—0·15	+0·44	+0·89	+1·01	+0·90	+0·69	+0·14

The form of the curve seems to suggest that these variations are due mainly to more rapid evaporation in the day time over the surface of the land than over the surrounding seas; but this idea affords no clue to the meaning of the very decided, and somewhat abrupt, decrease in the velocity of those winds about noon, and for about an hour before and after that time;—a diminution which is decidedly shown by the eastward bend about noon in figure 120, and the westward bend of figure 121. These deflections appear to indicate that the local systems of anti-convection currents, blowing outward from the middle of the Peninsula, are not altogether annihilated even when the summer monsoon is at its height; but have still sufficient strength to oppose the inward convection currents, and produce in the latter the diminution of velocity which takes place about noon.

The north components of the diurnal wind variations at Kurrachee and Calcutta in July and August are evidently very similar, as may be seen by an inspection of figures 120 and 121. In each case the hourly inequalities have positive values from 22 to 11 hours, reaching a maximum about 6 hours, and negative values from 12 to 21 hours, reaching a minimum at 16 hours, and the form of the curve representing the north component variations with time approximates to the form of a temperature curve. These variations are, therefore, mainly attributable to atmospheric convection produced by differences of temperature.

Rotations of the Wind Vane at Kurrachee.

The number of direct and retrograde rotations of the vane recorded in each month of the three years will be seen in the following table:—

TABLE LII.

Months.	1873.		1874.		1875.		Total.		Total excess of direct over-retrograde.
	Direct.	Retrograde.	Direct.	Retrograde	Direct.	Retrograde.	Direct.	Retrograde.	
January	9	1	14	2	12	0	35	3	+ 32
February	10	1	11	1	16	1	37	3	+ 34
March	1	0	2	2	5	0	8	2	+ 6
April	2	1	3	0	3	0	8	1	+ 7
May	0	0	1	0	1	1	2	1	+ 1
June	0	0	1	0	5	2	6	2	+ 4
July	0	0	2	1	4	2	6	3	+ 3
August	4	1	0	0	1	0	5	1	+ 4
September	0	0	1	2	0	0	1	2	− 1
October	4	2	5	3	7	0	16	5	+ 11
November	16	1	12	3	16	1	44	5	+ 39
December	17	2	15	0	15	2	47	4	+ 43
April to September ...	6	2	8	3	14	5	28	10	+ 18
October to March ...	57	7	59	11	71	4	187	22	+165
Year	63	9	67	14	85	9	215	32	+183

The number of direct rotations is very greatly in excess of the retrograde rotations, and this is the case in every month of the year, except September, in which the retrograde rotations appear to be slightly in excess. The excess of direct over retrograde movements is very much greater in the winter than in the summer half-year, but this is due chiefly to the great number of direct rotations in the months November to February; immediately before and after which the excess is abruptly reduced.

The explanation of these excesses is evidently the same as that which I have given for Bombay.[1] They are caused almost entirely by the *diurnal variation* of the wind, and occur at times when the daily resultant wind has a low velocity, and lies wholly within the range of the diurnal variation. An inspection of the figures 1 to 12 will be sufficient to show that this is the case. In the months November and December the lines representing the monthly resultant winds lie wholly within the diurnal variation curve, which has a right-handed or direct rotation. Consequently the daily resultant winds in these months will also frequently lie within the diurnal variation curve, and on all such days a single direct rotation of the vane will occur. In January and February, the lines representing the monthly resultant winds lie, throughout the greater portion of their lengths, within the diurnal variation curves; and many of the daily resultant winds of these months, of which the monthly resultants are the means, will also doubtless fall wholly within the closed curves; although their number will be less than in the two preceding months. Consequently, (the diurnal variations being still right-handed,) many direct rotations of the vane should occur, although not so many as in November and December; and this we find is the case. But in March, a great change has taken place in the length of the monthly resultant line, which now lies for the greater part of its length outside the diurnal variation curve. The same will be the case with most of the daily resultant lines; and therefore the number of rotations should show a decided diminution, as indicated by the numbers of the table. In the succeeding months, as the daily resultant wind grows stronger and the diurnal variation curves close in, the probability of the occurrence of direct rotations becomes smaller; and in September, when the daily resultant winds begin to grow weaker, and the diurnal variation curve is more open, but left-handed in the direction of its rotation, there is some probability of the occurrence of retrograde rotations, and this, we see from the table, is the only month in which retrograde rotations of the vane are in excess of direct rotations. In October, however, the direction of rotation of the diurnal variation is abruptly reversed, becoming again right-handed, and at the same time the daily resultant winds grow much weaker. Consequently the probability of the occurrence of direct rotations is again increased, and the direct rotations are once more in excess, as shown by the table.

Mean Hourly Velocity of the Mechanical Resultant Wind, and Mean Hourly Velocity of the Wind regardless of direction.

The mean hourly velocity of the mechanical resultant wind is given in the following table for each month, each half-year, and for the whole year, and graphically represented by the dotted curves 61 to 75. The hourly values have been calculated by the usual formula.

$$R = \sqrt{N^2 + E^2}$$

[1] *Vide* "Philosophical Transactions," 1873, pages 12 and 13.

TABLE LIII.

Mean Hourly Velocity (in miles per hour) of the Mechanical Resultant Wind at Kurrachee.

Hours	Mid-night	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23
January . . .	5.1	6.1	6.8	7.4	7.0	7.8	8.0	8.1	6.3	7.9	7.4	4.5	1.8	2.2	4.1	7.2	8.3	7.9	7.4	6.4	4.7	4.8	3.8	4.0
February .	6.1	6.0	6.6	6.5	6.9	5.9	6.3	6.4	6.3	5.2	3.6	0.7	1.0	7.0	9.0	11.3	11.5	11.9	11.0	9.8	7.9	7.2	6.6	5.8
March . . .	12.9	12.1	12.4	11.7	10.7	10.6	9.9	9.2	9.5	10.3	12.2	14.9	17.7	19.6	21.3	21.4	20.4	19.8	18.7	17.3	16.0	15.0	14.4	13.8
April . .	14.5	15.3	15.2	15.3	14.3	13.3	11.6	12.1	12.3	14.2	15.2	17.6	20.6	21.9	23.0	23.4	22.7	22.7	21.5	20.2	18.1	17.5	15.7	15.8
May . . .	16.8	16.6	17.1	16.2	15.5	15.7	15.3	16.2	16.3	17.2	19.0	20.7	21.8	23.2	23.9	24.4	23.7	23.4	21.9	19.2	17.8	16.3	16.3	16.8
June . .	20.7	20.1	21.5	20.1	20.6	19.0	19.8	19.5	19.9	20.8	21.5	22.0	23.8	24.3	25.6	25.8	26.9	25.4	25.0	23.6	22.8	22.0	21.2	21.3
July . . .	21.2	22.0	21.1	22.5	21.7	21.9	21.1	21.6	21.3	21.6	21.8	22.2	22.1	23.2	23.8	24.3	24.3	24.5	22.8	23.1	21.7	21.2	20.6	20.5
August . .	20.7	21.5	21.6	21.5	20.5	21.2	20.0	21.0	20.8	21.2	21.4	21.8	21.7	22.5	23.9	24.3	23.7	23.8	22.6	22.0	20.6	20.7	20.0	21.5
September .	15.7	15.3	14.8	15.0	14.8	14.8	14.6	15.7	15.4	17.8	18.0	19.2	19.4	19.8	20.5	19.6	19.4	18.0	16.2	15.5	14.1	14.8	11.8	14.9
October . . .	6.2	5.9	5.2	4.8	4.3	3.7	3.3	3.3	4.0	5.0	7.3	10.9	13.2	15.1	17.0	17.9	17.8	16.3	14.9	12.8	9.9	7.9	7.2	7.0
November . .	4.8	4.0	5.8	6.0	5.8	6.6	7.2	8.2	7.0	6.0	2.9	2.2	5.7	7.7	9.0	10.6	11.2	10.0	8.4	6.6	4.1	4.2	3.6	3.0
December . .	7.5	8.0	8.6	9.5	9.6	9.8	10.2	10.6	10.6	10.5	9.4	7.1	4.5	2.4	1.1	3.1	3.0	3.7	3.1	2.8	3.0	3.9	5.2	7.0
October to March .	5.3	5.4	5.6	5.7	5.5	5.3	5.5	5.6	5.3	4.3	1.7	2.6	5.5	8.2	10.2	11.8	12.2	11.6	10.4	8.8	6.9	6.2	5.7	5.4
April to September .	18.2	18.3	18.4	18.3	17.8	17.7	17.0	17.5	17.6	18.8	19.5	20.6	21.6	22.5	23.5	23.7	23.5	23.0	21.7	20.5	18.3	18.8	18.0	18.4
Year . . .	10.7	10.4	10.3	10.0	9.5	9.1	8.4	8.3	8.4	9.1	9.9	11.7	13.5	15.3	16.8	17.7	17.8	17.2	15.0	14.6	12.8	12.2	11.4	11.2

The mean hourly velocity of the wind (regardless of direction) for each month and for the whole year is given in Table IX, and exhibited by figures 46 to 60. If at homonymous hours in the same month the wind always blew from the same direction, the two sets of curves would of course be identical; and the more variable the wind direction is at homonymous hours of successive days of the same month, the more will the corresponding curves of the two sets differ from each other.

The diurnal variation curves of the resultant velocity of the wind from March to October, figures 63 to 70, differ very little from those of the wind velocity (regardless of direction,) but in the months November to February they differ very considerably. Hence, we may infer that, in the former months, the wind direction is very steady, particularly during the early afternoon hours, while in the latter months the wind is much more variable in direction, especially in the day time. The change of form in the diurnal variation curves of the mechanical resultant wind is of course merely the effect of the combined action of the annual and diurnal variations, but an inspection of these curves, and their comparison with those showing the variations of the velocity (regardless of direction), throws much light on the latter, and proves that the modification of form which they undergo from month to month is mainly due to the same causes as the change of form of the hourly resultant curves.

Comparison of the Wind and Rainfall at Kurrachee.

The rainfall at the Kurrachee Observatory during the three years 1873 to 1875 is given in the following tables:—

TABLE LIV.

Rainfall in inches at Kurrachee during the year 1873.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	...	...	...	...	...	...	...	...	...	...	...	...
2	1·20	...	...	...	...	...	...	0·08	...	...	...	...
3	0·15	...	...	...	...	...	...	0·11	...	...	...	...
4	0·02	...	...	...	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	...	...	...	...	...
6	...	...	...	...	...	...	...	0·09	...	...	...	...
7	...	...	...	...	...	...	...	0·01	...	...	...	...
8	...	...	...	...	...	...	...	0·34	...	...	...	...
9	...	...	...	...	0·03	...	...	...	...	...	...	...
10	...	...	0·01	...	...	...	...	...	...	...	...	...
11	...	...	...	...	...	...	...	...	...	...	...	...
12	...	...	...	...	...	...	...	...	...	...	...	...
13	0·01	...	...	...	...	...	...	...	...	...	...	...
14	...	...	...	...	...	...	...	...	...	...	...	...
15	...	...	...	...	...	...	...	...	...	...	...	...
16	...	...	...	...	...	...	...	...	...	...	...	...
17	...	...	...	...	...	...	...	...	...	...	...	0·07
18	...	...	...	...	...	...	...	...	...	...	...	...
19	...	...	...	...	...	...	...	...	...	...	...	...
20	...	...	...	...	...	...	...	0·01	...	...	...	...
21	...	...	...	...	...	...	...	...	...	...	...	...
22	...	...	...	...	...	...	...	...	...	...	...	...
23	...	...	...	...	...	...	...	...	...	...	...	...
24	...	...	...	...	...	...	...	...	...	...	...	...
25	...	...	...	...	...	...	...	...	...	...	...	...
26	...	...	...	...	...	...	...	...	...	...	...	0·25
27	...	...	...	...	...	...	...	...	...	...	...	...
28	...	...	...	...	...	...	...	...	...	...	...	...
29	...	...	...	...	...	...	...	...	...	...	...	...
30	...	...	...	...	...	...	...	...	...	...	...	...
31	...	...	...	...	...	...	...	...	...	...	...	0·12
...	1·38	...	0·01	...	0·03	...	...	0·64	...	...	...	0·44

Total for the year ... 2·50

TABLE LV.

Rainfall in inches at Kurrachee during the year 1874.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	0·19	...	...	...	...	...	...	...	...	...	...	...
2	...	...	...	...	...	...	0·11	...	...	...	...	...
3	...	...	...	...	...	...	...	0·27	...	...	...	...
4	...	...	...	...	...	...	...	0·40	...	...	...	...
5	...	0·10	...	...	...	...	0·02	0·26	...	...	...	...
6	...	...	...	...	...	...	...	...	...	...	...	...
7	...	...	...	...	...	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	...	...	...	...	...
9	...	...	...	...	...	...	...	...	...	...	...	...
10	...	...	...	...	...	...	...	...	...	...	...	...
11	...	...	...	...	...	0·17	...	...	...	...	...	...
12	...	...	...	...	...	...	...	...	...	...	...	...
13	...	...	...	...	...	...	0·58	...	...	...	...	...
14	...	...	...	...	...	...	...	...	...	...	...	...
15	...	...	...	...	...	...	...	...	...	...	...	...
16	...	...	...	...	...	...	0·06	0·02	...	...	...	...
17	...	...	...	...	...	...	1·84	...	...	...	...	...
18	...	...	...	...	...	...	0·10	...	...	...	...	...
19	...	...	...	...	...	0·70	0·67	...	...	...	...	...
20	0·03	...	...	...	...	...	0·66	...	...	...	...	...
21	0·21	...	...	...	...	...	...	0·02	...	...	...	...
22	...	...	...	...	...	...	...	...	...	...	...	...
23	...	...	...	...	...	...	...	...	...	...	...	...
24	...	...	...	...	...	...	0·15	...	...	...	...	...
25	...	...	...	...	...	...	0·02	...	...	...	...	...
26	...	...	...	...	...	...	...	...	...	...	...	...
27	...	...	...	...	...	...	0·61	...	...	...	...	...
28	...	...	...	...	...	...	0·89	...	...	...	...	...
29	...	...	...	...	...	...	0·13	...	...	...	...	...
30	...	...	...	...	...	...	0·03	...	...	...	...	...
31	0·12	...	...	...	...	...	0·18	...	...	...	...	...
TOTAL...	0·55	0·10	...	...	...	0·87	6·05	0·97	...	...	...	...

Total for the year ... 8·54

TABLE LVI.

Rainfall in inches at Kurrachee during the year 1875.

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	...	...	...	...	...	...	...	0·07	...	...	...	0·67
2	...	...	...	...	...	...	...	...	...	...	...	...
3	...	0·06	...	...	...	...	...	...	...	...	...	...
4	...	...	...	...	...	...	...	...	...	...	...	...
5	...	...	...	...	...	...	...	0·03	...	...	...	...
6	...	...	...	...	...	...	...	...	...	...	...	...
7	...	...	...	...	...	...	0·07	...	...	...	...	...
8	...	...	...	...	...	...	0·10	...	...	...	...	...
9	...	...	...	...	...	...	0·16	...	...	...	...	...
10	...	...	...	...	...	...	...	...	...	...	...	...
11	...	...	...	...	...	...	...	...	...	...	...	...
12	...	0·08	...	...	...	...	0·09	...	...	...	...	...
13	...	...	...	...	...	...	0·04	...	...	...	...	...
14	...	0·06	...	...	...	...	0·01	...	...	...	...	...
15	...	0·16	...	...	...	...	...	...	...	...	...	...
16	...	...	...	...	...	...	...	...	...	...	...	...
17	...	...	...	...	...	...	...	...	...	...	...	...
18	...	...	...	...	...	...	...	...	...	...	...	...
19	...	...	...	...	...	...	2·81	...	2·75	...	...	...
20	...	...	...	...	...	...	0·49	...	...	...	...	...
21	...	0·06	...	...	...	...	...	...	...	...	...	...
22	...	...	...	...	...	...	0·02	...	...	...	...	...
23	0·05	...	...	...	...	...	...	...	...	...	...	...
24	...	...	...	...	...	...	0·01	...	...	...	...	0·48
25	...	...	...	...	...	...	...	...	...	...	0·01	...
26	...	...	...	...	...	...	...	...	...	...	...	...
27	...	...	...	...	...	...	...	...	...	...	...	...
28	...	...	...	...	...	...	...	...	...	...	0·35	...
29	...	...	...	...	...	...	...	...	...	...	0·04	...
30	...	...	...	...	...	...	...	...	...	...	1·01	...
31	...	...	...	...	...	...	0·02	...	...	...	...	...
TOTAL...	0·05	0·42	...	...	...	...	3·82	0·10	2·75	...	1·41	1·15
									Total for the year		...	9·70

Comparing these tables with Tables I to III, it would appear that rain seldom falls so long as the summer monsoon wind continues to blow steadily, but that it usually falls during temporary cessations of that wind, or probably during cyclonic disturbances. The number of instances of rainfall during the three years is, however, too small to permit of any other very trustworthy conclusion being drawn than that the occurrence of rain at Kurrachee is comparatively rare—a fact which it is important to bear in mind in reasoning on rainfall generally, for it shows conclusively that a strong damp wind from the seaward is not the only condition required to produce rain. Indeed, it suggests that, under certain circumstances, a strong sea wind, such as that which blows during the summer at Kurrachee, may prevent rather than favour the production of rain.[1]

[1] Compare this with the facts deduced from a discussion of the winds of Calcutta in their relation to rainfall. See the passage in italics on page 20 of this volume.—H. F. B.

TABLE

Daily means of the North and East Components

(Velocity in miles

Date.	January.		February.		March.		April.		May.	
	North.	East.	North	East.	North.	East.	North.	East.	North.	East.
1	...	...	+ 2·7	− 29	− 21	−109	− 59	−135	− 82	−199
2	...	...	+ 20	+ 05	− 43	−16·9	− 60	−161	− 89	−21·4
3	...	...	...	...	− 3·5	−19·1	− 68	−153	−113	−21·5
4	+ 7·6	−121	+ 07	− 1·0	− 20	−144	− 26	−11·9	−11·4	−19·0
5	+11·5	− 48	− 06	− 83	− 1·2	−183	− 3·1	−101	− 94	−196
6	+164	− 82	− 44	−133	− 03	−15·1	− 1·3	−145	− 84	−200
7	+ 89	− 04	− 63	−219	− 20	−179	...	...	−103	−159
8	+ 04	+118	+ 25	+ 30	− 26	−175	...	...	− 78	− 99
9	+ 30	+ 39	+ 58	− 52	− 08	−177	...	...	− 85	−143
10	+ 40	+ 34	...	...	+ 20	−141	− 84	−202	− 48	−102
11	+ 04	+ 02	− 08	− 43	− 4·1	− 45	− 0·4	−206	− 55	−188
12	− 24	− 98	− 0·1	− 20	− 45	−14·5	...	...	−108	−20·4
13	− 35	− 55	+ 45	− 01	− 27	−188	+ 28	−121	− 88	−162
14	+ 20	− 06	− 14	− 52	− 3·7	−185	− 23	−11·0	− 67	−165
15	− 3·1	− 4·4	− 39	− 87	− 05	− 99	− 30	− 87	− 51	−149
16	− 5·3	−17·3	+ 1·0	− 57	− 1·6	−130	+ 23	− 64	− 1·6	−129
17	− 4·1	−258	+142	+ 68	− 1·8	−151	− 1·4	− 82	− 1·1	−145
18	+ 20	− 52	+ 2·8	+ 59	− 48	−17·9	− 1·7	− 73	− 02	−177
19	+11·3	+ 8·9	− 06	− 30	− 79	−183	− 49	−103	+ 02	−19·6
20	+ 74	− 1·6	+ 1·4	− 79	− 63	−233	− 77	−185	...	−202
21	+ 25	+ 39	− 20	− 66	− 78	−26·1	−125	−187	− 2·3	−20·6
22	+11·0	+ 50	− 51	−162	...	...	−12·8	−204	− 64	−160
23	+ 62	− 1·8	− 0·6	−206	− 1·4	−190	− 60	−233	− 65	−14·6
24	+ 1·7	− 28	...	...	− 01	− 84	− 78	−239	− 58	−157
25	+ 1·3	− 59	+ 69	−168	− 07	− 74	− 75	−261	− 29	−138
26	...	...	+11·3	−147	− 25	−120	− 69	−25·3	− 31	−192
27	...	...	+ 22	− 62	− 59	− 85	− 63	−242	− 38	−180
28	+ 1·4	− 58	+ 07	− 80	− 40	− 88	− 83	−255	− 49	−121
29	...	...	...	...	− 45	−141	− 84	−236	− 30	−157
30	+ 37	− 67	...	...	− 37	−11·0	−11·6	−218	− 76	−130
31	+ 09	−102	...	...	− 43	−129	...	...	−119	− 95

I.

of the Wind at Kurrachee in the year 1873.

per hour.)

June.		July.		August.		September.		October.		November.		December.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
−9·9	−10·6	−13·3	−28·4	−6·0	−13·8	−5·1	−16·2	−9·4	−11·6	+2·0	−2·4	−0·1	−1·5
−8·3	−17·6	−12·2	−29·4	−3·7	−12·6	−6·3	−18·9	−9·7	−16·0	+2·8	−2·0	+3·0	−1·9
−4·2	−21·9	−9·9	−22·3	−9·6	+0·8	−4·8	−17·3	−5·5	−6·4	+0·6	−2·9	+8·5	+7·1
−5·7	−23·3	−5·4	−18·6	−8·1	−9·0	−5·9	−14·9	−1·9	−10·4	+0·2	−3·1	+5·9	+8·8
...	...	−6·9	−18·1	−13·7	−12·0	−6·3	−13·9	+0·3	−11·3	+0·6	−1·7	+4·1	−1·2
...	...	−6·6	−19·6	−7·0	−5·8	−5·1	−13·6	...	...	+0·6	−1·4	+2·3	−1·1
−10·3	−17·7	−7·9	−23·1	−4·6	−7·2	−3·5	−17·6	−0·9	−11·7	+4·1	+4·1	+7·8	+3·9
−11·5	−14·4	−8·3	−23·5	...	...	−5·9	−22·1	−2·3	−7·6	+1·8	−8·1	+0·4	−4·0
−5·8	−14·6	−7·9	−21·9	−16·9	−25·3	−6·7	−19·8	+0·3	−9·0	−1·1	−2·9	+2·2	−5·6
−6·7	−14·6	−16·4	−18·5	−15·0	−22·2	−8·8	−21·2	−2·4	−13·6	−2·2	−9·8	+1·3	+0·9
−6·5	−24·9	−15·4	−23·4	−17·0	−20·5	−7·4	−19·5	−0·6	−11·2	+0·3	−9·2	+3·0	+1·2
−10·7	−22·1	−15·2	−22·6	−14·6	−27·7	−6·6	−18·6	−3·6	−7·1	+3·1	+4·0	+6·4	+9·3
−12·6	−17·1	−15·4	−18·9	−9·2	−30·6	−5·5	−19·5	−2·3	−7·2	+9·1	+6·2	+14·5	+9·0
−10,4	−17·7	−11·7	−21·4	−15·5	−25·5	−5·0	−17·3	−1·5	−6·5	+0·2	−3·3	+9·5	+2·7
−6·5	−26·4	−15·0	−27·6	−12·5	−25·5	−3·1	−19·1	...	...	+6·3	+6·3	...	...
−7·1	−31·3	−16·2	−21·7	−8·8	−28·9	−3·5	−15·7	−1·9	−6·2	+7·1	+6·1	...	...
−9·3	−26·5	−17·8	−22·7	−6·7	−24·8	−6·4	−8·8	...	...	−1·2	−4·3	+1·6	+1·6
...	...	−18·2	−25·9	−12·1	−25·2	−7·8	−9·6	+2·8	−3·0	−0·9	−4·8	+4·7	+4·4
...	...	−16·5	−25·8	−13·7	−26·6	−4·9	−17·7	−1·6	−6·9	+2·5	−1·9	+6·5	+3·7
...	...	−13·3	−25·8	−8·0	−30·6	−4·5	−25·3	−2·7	−7·9	+9·2	+8·2	+2·1	+2·2
...	...	−10·4	−23·1	−2·3	−27·5	−5·1	−22·5	−0·7	−10·3	+3·9	−0·6	+10·5	+12·4
...	...	−12·9	−26·1	−3·7	−20·8	−3·4	−16·7	−2·2	−7·6	...	...	+14·7	+12·5
...	...	−15·9	−25·8	−4·7	−14·4	−2·4	−16·0	−2·2	−6·7	...	...	+3·4	−1·7
−12·6	−14·7	−10·7	−15·0	−5·4	−13·2	−3·2	−17·0	−2·3	−9·7	+0·7	−2·9	+0·5	+20·
−13·5	−18·1	−7·8	−10·9	−7·6	−12·1	−4·7	−16·7	−4·1	−6·4	+5·4	−2·8	+4·8	+6·4
−13·2	−18·4	−13·5	−16·8	−2·7	−14·3	−7·9	−16·9	−3·4	−8·8	+12·0	+9·1	+13·3	−8·2
−13·3	−18·9	−17·1	−22·8	+0·1	−17·5	−3·7	−19·1	−2·5	−10·7	+15·6	+10·7	−0·7	+2·5
−15·8	−20·7	−22·0	−22·8	−4·5	−15·9	−3·8	−20·0	+0·6	−4·0	+5·8	−1·9	−1·0	+0·8
−16·5	−22·0	−17·1	−22·0	−5·8	−12·9	−1·6	−16·0	+1·7	−4·6	−1·5	−5·1	−1·4	+2·0
−17·8	−20·9	−18·8	−25·4	−6·1	−14·7	−3·5	−8·9	+0·4	−3·8	−4·5	−3·5	+0·9	−10·8
...	...	−16·3	−27·5	−5·0	−12·8	...	...	+2·0	−5·0	...	...	−0·6	+4·3

TABLE

Daily means of the North and East Components

Velocity in miles

Dates.	January.		February.		March.		April.		May.	
	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
1	+ 5·1	− 9·9	− 1·2	+ 1·1	+ 0 5	− 1·1	− 4·0	−19·2	− 7·7	−16 2
2	+ 5·8	− 5·9	− 0·1	+ 1·2	− 0·7	− 5·1	− 4 0	−17·5	− 3 1	−12 5
3	+ 2·5	+ 0 9	− 1·9	− 2·4	− 7·3	−20·5	+ 0·5	− 5·1	−10 1	−17·5
4	+ 9·3	+11·4	− 6·3	−10·1	− 8·4	−16 4	− 2·4	− 8·0	−13·8	−17·4
5	+ 9·3	+11·8	+ 1·0	+15·7	− 8·7	−16·4	− 5·2	−19·4	−10·8	−15·6
6	+ 3·3	+ 6·3	− 3·4	− 1·5	− 5·3	−15·0	− 7·8	−21·6	− 6 9	−15·3
7	− 1·2	− 7·1	− 4·0	− 1·6	...	...	− 6·1	−19·5	− 5·5	−16 1
8	+ 4·9	− 0·4	− 5 0	− 8·7	− 4·5	−19·2	− 7·9	−19·2	− 1·8	−13 2
9	+ 9 5	+ 8·1	− 6 6	−20·5	− 0·8	− 0·9	− 9·7	−16·9	− 4·2	−14·7
10	+ 5·9	+ 2·2	+11·9	−19·5	+ 1·5	+10·0	− 8·9	−20 7	− 8·6	−11·4
11	+17·5	− 1·7	+ 8 0	−14 6	+ 5·9	+ 5·9	− 5·5	−19·5	− 5·1	−15·8
12	0·0	+ 0·9	+ 5·9	− 2·8	− 0·1	− 4·1	− 1·6	−14·9	− 4·3	−19 6
13	− 2·1	+ 2·3	+ 0·7	− 3·3	− 4·6	− 8·3	+ 1·1	− 7·7	...	...
14	− 1·5	+ 6·1	− 1·0	− 2·0	− 5·6	−17·3	− 4·2	− 8·1	...	...
15	+ 5·4	− 4·5	+ 0·5	− 3·6	− 2·9	−20·5	− 4·2	−14·4	− 5·6	−17·9
16	+ 1·8	+ 1·3	− 3·3	−11·8	+ 4·9	−14·7	− 0·9	−10·2	−10·2	−17·3
17	...	...	+ 1·1	− 7·6	− 2·0	−19·7	− 2·6	−13·0	−10·4	−15 3
18	...	...	+ 0·4	− 3·3	− 5·0	−18·0	− 6·2	− 8·9	...	...
19	...	...	− 0 8	−10·6	− 1·0	−19·8	−10·1	−15·1	−10·4	−13·1
20	− 2·8	+10·1	− 1·1	− 7·7	− 2·0	−20·4	− 9 3	−16·1	− 8·5	−20·4
21	...	...	− 0·7	− 4·5	− 6·1	−23·0	− 6·8	−15·8	− 9 1	−21·8
22	...	...	+ 0·4	− 5·6	+ 1·3	−33·3	− 2·5	−15·8	− 8·4	−16 8
23	+ 2·3	− 1·7	+ 2·0	− 5·4	+ 4·7	−22·5	− 6·3	−14·9	−12·5	− 9·6
24	+ 6·9	+15·0	− 0·2	− 5·4	+ 2·0	−11·9	− 5·9	−11·5	−11·2	−10·4
25	+ 5·3	+10·4	− 0·7	− 5·1	− 3·7	−14·5	− 5·8	−15·6	−15·7	−15·4
26	+ 7·9	+17·5	+ 1·5	−13·0	− 4·0	−16·9	−10 0	−14·2	−13·5	−18 1
27	+16 8	+21·3	+ 1·7	− 4·4	− 2·3	−10·2	...	...	− 9·9	−19 6
28	+ 8·1	+ 7·5	+ 0·2	− 3·5	− 3·1	− 9·9	−13·9	−18·0	−10·6	−16 0
29	− 1·5	− 1·5	...	...	− 8·1	−13·3	−13·2	−19·7	−13 0	−22·2
30	+ 1·5	− 2·3	...	...	−13 0	−21·0	− 9·3	−14·6	−10·5	−25·9
31	− 1·3	0 0	...	...	− 2·4	−18·1	...	...	−13·1	−16 2

II.

of the Wind at Kurrachee in the year 1874.

per hour).

June.		July.		August.		September.		October.		November.		December.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
−11·0	−14·6	−15·7	−20·1	− 7·2	−21·6	−4·2	−25·4	− 5·8	−20·3	+0·2	− 1·9	− 0·2	− 7·0
−11·2	−22·0	−14·3	−23·3	− 8·2	−17·3	−2·2	−18·4	− 2·0	−19·8	+2·3	− 2·6	+ 0·9	− 1·0
− 6·7	−25·9	−14·7	−24·9	− 3·9	−13·2	−5·2	−18·8	− 5·8	−13·9	+1·0	− 4·2	− 1·2	− 3·2
− 8·4	−23·5	−17·0	−27·9	− 3·1	−16·6	−3·4	−18·2	− 9·0	−11·5	+1·0	− 3·2	− 1·7	− 6·7
− 8·8	−17·8	...	...	− 8·1	−21·3	−3·3	−15·3	−10·0	−13·7	−4·0	− 3·1	− 1·8	− 6·6
− 7·4	−14·1	−15·3	−23·7	−12·3	−19·9	−0·6	−16·2	− 4·5	−10·9	−0·1	− 6·3	+ 3·7	+ 1·3
− 4·0	−11·2	−18·4	−21·6	−14·4	−23·9	−1·0	−13·5	− 3·3	− 5·9	−2·4	− 7·9	+12·6	+ 7·5
−10·2	−14·8	−18·0	−18·5	−14·3	−21·8	−2·8	−12·5	− 3·5	−13·3	..	...	+13·3	+ 4·3
− 8·3	−12·0	−15·4	−15·8	−16·2	−23·9	−2·0	−13·8	− 5·8	− 0·4	−1·8	− 5·2	+12·6	+ 8·1
− 2·2	+ 1·3	...	...	−11·5	−18·1	−1·0	−15·2	− 1·6	− 6·1	−0·9	− 5·2	+ 6·2	+ 6·4
− 7·0	+ 5·2	−14·5	−16·5	...	...	−2·6	−13·9	− 2·5	−10·1	+1·6	+ 1·8	+10·3	+ 9·6
−12·5	− 6·5	− 6·8	− 6·5	− 6·4	−19·6	−3·6	−15·7	− 1·7	− 8·6	+2·9	− 0·6	+ 7·6	+ 3·4
−15·0	−17·1	− 0·5	− 7·4	− 5·6	−22·0	−1·1	−14·1	+ 2·0	− 0·7	−0·2	− 1·4	+ 3·8	+ 5·4
−12·5	−17·9	...	...	...	...	−2·2	−11·0	− 1·1	− 5·5	+1·4	− 1·6	+ 2·8	+ 5·0
− 4·5	−16·5	−10·9	−19·5	− 8·8	−18·4	−2·1	−15·6	− 4·6	− 5·8	−1·5	− 2·9	− 2·1	− 2·4
− 5·4	−16·8	−13·7	−29·0	− 4·8	−17·1	−3·4	−15·4	− 2·7	− 1·9	+2·3	− 3·5	+ 1·5	0·0
− 7·1	−15·0	− 7·5	−18·5	...	...	−4·3	−14·4	− 2·7	− 7·2	−1·5	− 3·7	+ 5·6	+ 1·1
−11·3	−16·2	...	...	−12·0	−19·4	−5·1	−12·6	− 1·6	− 7·9	...	...	+11·1	+12·9
− 3·1	−23·9	− 5·0	−19·2	−11·6	−25·2	−5·8	−10·7	− 2·3	−11·6	−2·1	− 1·1	+12·5	+11·8
− 8·4	−27·8	...	...	−12·3	−23·3	−5·3	−17·1	− 1·0	− 9·8	+1·1	− 1·8	+ 5·6	0·0
− 5·1	−25·5	− 7·1	−25·7	...	...	...	...	− 1·5	− 9·9	−2·0	− 5·3	+11·0	− 2·4
− 5·8	−24·8	− 7·7	−22·5	−12·1	−22·4	−6·7	−14·5	− 2·0	− 7·1	−2·7	−10·0	+ 3·2	− 2·4
−11·6	−25·2	− 6·6	−20·5	− 9·1	−19·2	−2·8	−12·1	− 1·0	− 8·4	−2·9	− 1·6	+ 3·9	− 1·9
−16·0	−26·3	− 7·6	−18·2	...	...	−1·1	−17·8	− 1·1	− 8·8	−1·1	− 4·4	+ 5·2	− 1·7
−19·9	−23·8	− 6·5	−13·0	− 7·8	−23·9	−2·5	−14·4	− 1·4	− 3·4	−0·4	− 2·5	+ 4·5	− 3·9
−11·7	−24·4	0·0	− 8·0	...	...	−4·7	− 7·1	− 3·3	− 3·7	−2·2	− 4·8	+ 2·0	− 2·2
−14·9	−29·8	+15·2	+ 6·0	− 7·1	−16·6	−7·0	−11·3	− 2·4	− 1·8	−0·4	− 1·7	+ 1·0	− 0·9
...	...	−14·3	+11·7	− 7·3	−13·8	−8·5	−17·7	+ 7·9	+ 1·6	−0·9	− 4·0	+ 6·2	+ 4·5
−17·2	−25·9	− 9·6	− 5·1	− 4·7	−12·9	−9·2	−17·2	− 1·5	− 6·3	−1·9	− 3·6	+ 1·6	+ 1·0
−16·1	−21·9	−13·3	−11·0	− 6·7	−21·4	−3·7	−18·7	− 1·4	− 4·5	+0·9	− 3·0	+ 2·5	− 2·3
	...	−10·3	−20·2	− 7·1	−25·8	...	...	− 2·1	− 3·8	...	...	+ 3·1	+ 0·7

TABLE

Daily Means of the North and East Components

Velocity in

Dates.	January.		February.		March.		April.		May.	
	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
1	+ 5·4	— 0·3	— 2·9	— 3·5	— 2·5	—10·2	— 6·4	—13·6	—11·6	—25·7
2	— 2·2	— 0·4	— 4·2	— 4·7	— 3·7	— 6·9	— 9·4	—13·4	— 8·1	—22·0
3	— 1·1	— 1·0	+ 8·3	—12·6	— 5·1	—14·7	—10·1	—15·3	— 7·6	—17·3
4	— 0·1	— 3·8	+ 3·8	— 0·8	— 4·8	—11·1	— 8·2	—11·8	— 6·6	—16·6
5	— 2·0	— 4·0	+12·7	+10·2	— 9·9	— 7·5	— 7·1	—16·7	— 5·1	—19·6
6	— 5·1	— 8·5	+ 6·1	+ 1·2	—12·1	—12·9	— 9·4	—18·0	— 3·9	—16·9
7	— 7·3	—14·3	+ 4·2	+ 3·6	— 6·2	—13·4	— 7·0	—20·1	— 3·7	—20·3
8	— 1·5	— 0·2	+ 1·5	— 5·6	— 2·1	—17·0	— 5·8	—20·6	— 6·5	— 8·8
9	— 1·1	— 3·2	+ 0·9	—10·3	— 3·2	—16·5	— 4·7	—21·6	— 4·6	—19·1
10	— 3·3	— 0·9	— 0·5	— 6·6	— 2·3	—17·8	— 3·3	—20·3	— 2·6	—14·4
11	— 2·9	— 0·9	+ 8·9	+ 9·6	— 4·2	—16·3	— 3·8	—15·5	— 4·2	— 6·5
12	— 2·5	— 2·1	+ 4·3	+ 8·5	— 8·6	—17·2	— 3·9	—19·0	— 6·6	— 8·0
13	— 4·0	—13·2	+28·2	+13·4	— 6·8	—19·1	+ 0·6	—28·6	— 6·2	—23·0
14	+ 2·2	—17·7	+ 7·5	+12·5	— 4·9	—17·4	— 5·2	—11·8	— 5·4	—28·7
15	+ 6·4	— 8·6	+ 4·9	— 5·1	— 4·4	—15·2	+ 2·6	— 8·7	...	...
16	+ 4·1	— 9·2	+ 4·3	— 5·6	— 3·0	—16·6	+ 3·0	— 3·7	...	...
17	+ 1·8	— 6·6	— 1·6	— 3·1	...	...	+ 2·6	— 5·1	— 3·1	—18·1
18	+ 4·6	—15·0	— 1·2	— 5·4	— 2·5	— 7·6	— 0·1	— 9·0	— 5·2	—15·9
19	+12·5	—12·1	— 0·2	+ 0·8	— 1·6	— 6·2	— 2·8	—14·0	— 7·6	—14·8
20	+10·4	+ 3·4	— 1·8	— 4·6	+ 0·4	— 8·1	...	...	...	...
21	+ 4·1	+ 0·7	+ 0·1	—11·0	— 0·8	— 9·3	— 7·4	—13·4	— 8·2	—18·7
22	— 0·6	— 4·8	+ 2·7	— 8·9	+ 0·7	—11·0	— 9·0	—13·7	— 5·6	—22·5
23	+ 2·4	— 1·6	— 2·1	— 2·2	— 2·6	—12·6	— 4·5	—14·0	— 4·4	—13·2
24	+ 5·1	— 4·2	+ 1·2	— 4·6	— 4·8	—10·7	— 5·6	—17·0	— 4·4	—22·0
25	+ 6·7	— 1·1	+ 5·7	+ 6·0	— 6·1	—10·4	— 6·7	—19·6	— 3·8	—22·7
26	— 2·1	+ 0·6	+ 7·9	+ 3·9	— 5·9	— 3·8	— 6·6	—20·3	— 5·1	—24·5
27	0·0	— 1·1	— 1·2	— 3·1	— 6·2	— 9·3	— 7·4	—21·8	— 6·2	—23·3
28	+ 0·2	— 3·7	+ 3·3	— 8·7	— 5·2	—14·9	— 8·7	—24·4	—11·0	—22·8
29	+ 8·7	— 9·4	...	...	— 4·4	—15·4	—10·1	—25·3	—13·4	—21·0
30	+ 1·3	— 6·1	...	...	— 1·4	—20·5	— 6·4	—20·9	— 8·8	—21·2
31	+ 0·9	— 1·2	...	...	— 2·4	—18·4	...	...	— 2·1	—23·0

III.

of the Wind at Kurrachee in the year 1875.

miles per hour):

June.		July.		August.		September.		October.		November.		December.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
—6·8	—19·7	—15·4	—25·1	—15·6	—23·1	—7·2	—16·5	—6·1	—11·4	+2·7	—4·6	...	...
...	...	—12·2	—29·4	—22·2	—22·2	—7·3	—15·6	—9·7	—11·8	—0·3	—2·4	+2·8	+3·7
...	...	—11·0	—27·2	—17·9	—22·5	—6·6	—14·5	—11·2	—16·2	...	...	+0·8	—1·4
—3·1	—21·3	—9·1	—23·1	—19·1	—23·5	—8·9	—14·7	—15·0	—22·7	+0·3	—1·8	+0·1	—1·2
—6·7	—6·0	—13·9	—19·0	—18·1	—21·7	—7·1	—17·2	—12·4	—22·1	—1·7	—0·2	+2·5	—0·8
—11·1	—11·3	—9·2	—16·4	—12·2	—24·5	—10·5	—13·3	—6·4	—13·4	—2·3	—4·7	+9·6	+5·9
—10·8	—7·8	—2·0	—6·3	—7·3	—21·3	—8·5	—15·7	—0·2	—2·7	—2·9	—5·9	+15·6	+8·6
—5·9	—10·2	—6·5	+5·2	—10·1	—16·2	—7·7	—18·5	—0·8	—4·1	—2·5	—7·7	+7·4	+5·1
—6·0	—11·7	—13·2	+0·9	—11·4	—11·5	—7·3	—17·6	—3·3	—3·4	—0·8	—6·2	+7·4	+6·8
—8·3	—13·0	—15·7	—29·4	—10·4	—13·9	—7·4	—11·6	—3·1	—5·4	—2·9	—7·7	+9·4	+14·0
—11·4	—16·5	—10·1	—23·1	—12·7	—21·0	—8·0	—14·2	—3·9	—8·4	—3·9	—7·8	+0·6	—1·0
—11·0	—27·6	...	...	—9·9	—21·4	—6·2	—16·2	—6·5	—8·2	+1·2	—5·6	+2·9	—0·9
—12·8	—32·5	...	...	—10·1	—23·2	—9·4	—20·2	—7·0	—10·0	+0·7	+2·2	+3·5	+0·6
—12·7	—30·7	...	...	—11·5	—24·5	—8·1	—12·1	—4·3	—10·0	—1·4	—0·8	+8·4	+5·9
—11·1	—31·0	—14·4	—23·3	—10·2	—26·8	—9·0	—10·7	—3·5	—10·8	—1·3	—4·4	+4·1	—4·1
—11·4	—27·8	—15·7	—21·9	—9·2	—27·1	...	...	—5·1	—10·9	—2·4	—4·8	+2·5	—1·9
—6·6	—19·7	—9·8	—19·8	—6·5	—27·2	—2·1	—10·3	—6·9	—9·7	+0·2	—3·3	+6·5	+2·9
—4·9	—13·6	—7·1	—15·2	—4·2	—22·5	+7·8	+3·6	—6·1	—7·2	+0·9	—2·7	+8·3	+0·4
—5·5	—19·8	—13·2	—25·1	—8·6	—14·1	+2·9	—5·7	—4·1	—8·1	...	...	—3·0	—0·6
—7·2	—23·6	—7·9	—11·8	—10·6	—8·4	...	...	—9·2	—12·0	...	...	—1·8	—8·9
—8·7	—23·4	—9·6	—10·4	—11·1	—11·6	...	...	—0·4	—2·7	...	...	—8·7	+7·8
—7·6	—30·7	—10·1	—15·0	—14·8	—21·3	...	...	+2·5	—5·5	...	...	+6·9	+6·0
—10·6	—31·8	—11·2	—18·4	—14·9	—23·7	—12·0	—23·0	—0·2	—4·0	...	...	+1·7	+6·4
—8·4	—25·0	—12·6	—21·9	—15·7	—23·0	—11·4	—14·8	+1·3	—3·7	...	...	+7·0	+0·7
—9·8	—21·7	—3·9	—27·4	—15·2	—21·6	—11·4	—11·6	—0·5	—1·8	...	...	+11·6	+11·8
...	...	—3·6	—19·2	—9·6	—20·2	—12·0	—19·6	—1·1	—3·8	...	...	+2·7	+4·8
...	...	—7·6	—12·3	—6·0	—18·1	...	...	—3·4	—7·4	+2·8	+6·9	+3·6	—7·7
—7·4	—30·6	...	...	—5·8	—17·6	...	...	—4·6	—8·1	+2·9	+8·8	+6·9	—6·5
—13·3	—28·1	...	...	—7·3	—15·1	—5·9	—20·6	—4·2	—6·2	+10·8	+12·1	+11·6	+13·9
—15·1	—22·8	—16·9	—24·6	—3·7	—16·4	—5·4	—14·0	—3·1	—7·9	...	...	+3·0	+1·6
...	...	—20·1	—24·7	—4·7	—16·3	...	...	—1·1	—5·0	...	...	+5·7	—0·3

TABLE

Monthly, Half-yearly, and Yearly Means of the Hourly and Daily Values of the

(Velocity in

Hour.	January.		February.		March.		April.		May.		June.		July.	
	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North	East.
Midnight.	+5·8	−2·1	+5·2	−5·2	+1·2	−12·6	− 2·8	−14·5	− 3·5	−15·4	− 8·7	−17·5	−10·9	−21·3
1	+6·4	−2·0	+6·0	−5·0	+1·3	−12·1	− 3·2	−16·2	− 4·3	−16·4	− 8·3	−18·9	−11·5	−21·9
2	+7·9	−2·1	+7·0	−4·5	+1·0	−12·3	− 1·4	−14·8	− 3·1	−15·1	− 8·8	−19·3	−10·3	−21·8
3	+8·7	−2·3	+6·8	−4·4	+1·1	−12·6	− 1·2	−16·3	− 2·8	−15·5	− 7·7	−19·7	−11·1	−23·1
4	+8·5	−2·3	+7·5	−2·9	+1·0	−11·3	− 1·2	−14·8	− 2·8	−13·0	− 7·4	−19·1	−10·2	−21·5
5	+9·1	−2·1	+6·4	−2·0	+1·0	−11·5	− 0·2	−14·8	− 2·1	−14·3	− 7·4	−19·7	−10·6	−23·4
6	+8·9	−1·1	+5·8	−2·4	+1·1	−10·3	− 0·9	−12·8	− 2·6	−13·9	− 7·1	−19·4	− 9·8	−21·6
7	+9·0	−0·3	+5·9	−2·2	+1·1	− 9·5	− 0·9	−13·2	− 2·9	−14·9	− 6·5	−18·3	− 9·7	−22·8
8	+8·2	+0·9	+4·2	−1·4	+0·7	− 9·9	− 0·9	−12·4	− 3·8	−13·6	− 7·0	−19·4	−10·1	−23·1
9	+8·6	+1·6	+2·6	−0·1	−1·3	−12·2	− 2·9	−14·3	− 5·0	−15·4	− 8·7	−20·6	−10·9	−21·6
10	+7·0	+1·3	+0·5	−1·6	−3·1	−14·2	− 4·9	−12·1	− 6·4	−16·4	− 9·3	−20·5	−12·2	−22·9
11	+4·5	+0·5	−2·3	−3·3	−6·1	−15·9	− 7·4	−16·6	− 8·5	−17·5	−10·6	−19·5	−13·5	−23·0
Noon	+1·5	−2·6	−5·1	−7·2	−8·1	−17·5	− 9·1	−18·0	− 8·7	−17·7	−12·1	−19·9	−13·9	−23·3
13	−1·8	−4·1	−6·9	−9·0	−9·1	−18·9	−10·3	−20·4	−10·7	−19·9	−12·4	−21·1	−15·9	−21·2
14	−3·4	−5·5	−7·5	−11·4	−8·1	−20·9	− 9·9	−20·4	−10·8	−19·2	−13·0	−20·1	−15·0	−23·7
15	−5·4	−8·8	−5·8	−13·7	−9·0	−21·7	−10·6	−21·8	−11·5	−19·9	−14·4	−21·0	−17·3	−24·6
16	−4·9	−9·5	−4·6	−13·3	−8·0	−19·7	− 9·3	−20·6	−10·3	−19·6	−14·9	−21·2	−17·1	−23·4
17	−3·4	−10·3	−3·1	−13·3	−8·0	−20·0	−10·4	−22·8	−11·1	−20·0	−14·9	−21·4	−18·5	−24·6
18	−0·6	−9·2	−0·3	−11·5	−6·0	−17·2	− 9·3	−20·4	− 8·8	−18·6	−14·5	−20·4	−16·0	−20·7
19	+0·4	−8·8	+0·5	−11·2	−4·1	−16·9	− 9·0	−19·4	− 7·1	−18·4	−12·8	−20·1	−18·0	−22·0
20	+0·9	−5·8	+0·7	−8·5	−3·1	−14·4	− 6·8	−17·6	− 6·1	−15·7	−12·1	−18·4	−14·0	−19·9
21	+2·0	−6·0	+1·7	−8·4	−2·1	−14·8	− 6·5	−16·9	− 5·2	−15·6	−11·0	−20·7	−14·7	−22·1
22	+2·1	−4·4	+3·2	−7·6	−1·0	−14·4	− 4·4	−15·3	− 3·6	−14·4	−10·6	−19·6	−14·3	−20·3
23	+5·4	−3·4	+4·5	−6·1	−0·2	−14·6	− 4·5	−16·7	− 4·3	−15·8	− 8·7	−19·9	−12·8	−22·5
Mean	+3·6	−3·7	+1·4	−6·5	−2·8	−14·8	− 5·3	−16·8	− 6·0	−16·5	−10·4	−19·8	−13·3	−22·6

IV.

North and East Components of the Wind at Kurrachee in the year 1873.
miles per hour).

August.		September.		October.		November.		December.		October to March.		April to September.		Year.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
– 6·9	–16·7	–4·6	–16·2	+0·9	– 5·7	+6·1	–1·3	+6·6	+1·9	+4·3	– 4·2	– 6·2	–16·9	–0·9	–10·5
– 6·1	–18·7	–3·9	–17·4	+1·3	– 5·2	+5·9	0·0	+7·4	+2·3	+4·7	– 3·7	– 6·2	–18·2	–0·7	–10·9
– 5·4	–18·8	–2·8	–16·1	+1·1	– 5·2	+6·5	+0·3	+7·6	+2·2	+6·2	– 3·6	– 5·3	–17·6	+0·4	–10·6
– 6·7	–18·0	–2·0	–17·3	+0·9	– 4·6	+7·4	+1·2	+8·8	+2·8	+5·6	– 3·3	– 5·2	–18·3	+0·2	–10·8
– 6·2	–16·5	–1·4	–16·8	+1·6	– 3·7	+7·4	+1·4	+9·0	+3·2	+5·8	– 2·6	– 4·8	–16·9	+0·5	– 9·7
– 7·0	–18·0	–1·5	–17·3	+2·4	– 2·7	+8·0	+2·2	+8·7	+4·7	+5·9	– 1·9	– 4·8	–17·9	+0·5	– 9·9
– 4·7	–16·8	–1·2	–15·6	+2·6	– 1·9	+8·5	+3·3	+8·6	+ ·5	+5·9	– 1·1	– 4·4	–16·7	+0·7	– 8·9
– 5·4	–18·1	–1·1	–16·6	+2·4	– 2·0	+9·2	+3·5	+9·0	+5·5	+6·1	– 0·8	– 4·4	–17·3	+0·8	– 9·0
– 6·0	–17·2	–1·7	–16·0	+2·6	– 3·6	+8·2	+3·8	+8·6	+5·8	+5·4	– 0·7	– 4·2	–16·9	+0·6	– 8·8
– 7·8	–19·6	–4·2	–18·3	+0·9	– 4·9	+7·9	+4·1	+8·0	+6·8	+4·4	– 0·8	– 6·6	–18·8	–1·1	– 9·8
– 8·5	–18·3	–5·1	–18·0	–2·0	– 7·4	+4·0	+4·5	+6·9	+7·2	+2·2	– 1·7	– 7·7	–18·0	–2·7	– 9·8
– 9·7	–19·7	–6·2	–19·8	–5·9	– 9·9	+0·2	+3·9	+4·4	+5·9	–0·9	– 3·1	– 9·3	–19·3	–5·1	–11·2
–10·0	–19·4	–5·7	–19·9	–8·3	–11·8	–4·6	+1·5	+0·7	+4·3	–4·0	– 5·5	– 9·9	–19·7	–6·9	–12·6
–11·8	–20·3	–6·5	–20·3	–8·8	–13·1	–5·9	+0·3	–0·8	+1·5	–5·5	– 7·2	–11·3	–21·0	–8·4	–14·1
–11·4	–19·6	–7·9	–19·8	–8·3	–15·2	–4·7	–3·0	–1·1	–0·7	–5·5	– 9·4	–11·3	–20·5	–8·4	–14·9
–11·3	–20·6	–7·2	–18·9	–8·4	–15·5	–4·9	–5·5	–2·8	–2·7	–6·0	–11·3	–12·0	–21·2	–9·0	–16·2
–11·1	–19·2	–8·1	–18·2	–7·4	–16·1	–3·4	–6·6	–1·9	–3·7	–5·0	–11·5	–11·8	–20·4	–8·4	–15·9
–11·7	–21·2	–8·8	–17·6	–6·2	–14·1	–1·4	–5·2	–0·3	–3·8	–3·7	–11·1	–12·6	–21·3	–8·1	–16·2
–10·4	–18·5	–8·0	–16·1	–4·6	–12·1	0·0	–4·6	+0·5	–1·8	–1·8	– 9·4	–11·3	–19·1	–6·5	–14·2
–10·7	–17·5	–7·6	–15·5	–3·4	–11·1	+1·2	–3·3	+1·5	+0·1	–0·6	– 8·5	–10·9	–18·8	–5·7	–13·6
– 8·6	–16·6	–7·4	–14·3	–1·5	– 9·3	+2·2	–2·2	+2·2	+1·2	+0·2	– 6·5	– 9·2	–17·1	–4·5	–11·8
– 8·8	–17·1	–7·4	–16·0	–0·2	– 7·8	+3·7	–2·2	+3·6	+1·5	+1·4	– 6·3	– 8·3	–18·1	–3·7	–12·2
– 7·2	–16·1	–6·0	–15·1	–0·1	– 7·6	+3·7	–1·1	+5·3	+0·7	+2·2	– 5·7	– 7·7	–16·8	–2·7	–11·2
– 7·2	–17·6	–5·6	–16·6	+0·6	– 7·0	+5·3	–0·6	+6·3	+1·6	+3·6	– 5·0	– 7·2	–18·2	–1·8	–11·6
– 8·4	–18·3	–5·0	–17·2	–1·9	– 8·2	+2·9	–0·2	+4·4	+2·2	+1·3	– 5·2	– 8·1	–18·5	–3·4	–11·8

TABLE

Monthly, Half-yearly, and Yearly Means of the Hourly and Daily Values of the

(Velocity in

Hour.	January.		February.		March.		April.		May.		June.		July	
	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
Midnight	+6·0	+3·9	+1·9	- 6·2	-1·0	-15·7	-2·7	-12·9	-7·4	-15·4	- 8·1	-18·0	-9·9	-15·9
1	+6·3	+3·8	+2·6	- 4·0	+0·5	-13·7	-1·6	-14·0	-5·9	-14·9	- 7·2	-16·6	-10·7	-15·5
2	+7·2	+5·1	+2·8	- 4·1	+1·0	-14·6	-1·5	-14·5	-5·5	-15·5	- 8·8	-18·5	-9·7	-15·2
3	+7·0	+4·6	+3·6	- 3·3	+1·9	-11·8	-1·8	-13·9	-4·7	-15·0	- 6·7	-16·7	-10·7	-17·5
4	+8·0	+5·4	+4·8	- 2·3	+2·0	-11·1	-0·9	-13·4	-5·1	-14·4	- 6·4	-18·8	-9·7	-17·3
5	+7·6	+5·3	+3·9	- 1·2	+2·1	-10·1	-0·2	-11·6	-6·1	-14·5	- 5·2	-18·6	-8·0	-18·7
6	+7·6	+6·3	+5·0	+ 0·6	+2·9	- 9·8	0·0	-10·0	-5·3	-14·6	- 4·7	-17·7	-6·6	-17·8
7	+8·0	+5·1	+5·1	+ 1·5	+3·5	- 9·0	-0·6	-10·3	-5·2	-14·9	- 4·9	-18·0	-8·3	-16·5
8	+8·8	+5·2	+5·2	+ 1·7	+2·3	- 8·9	-2·6	-11·0	-6·8	-15·9	- 5·2	-17·6	-7·3	-16·2
9	+8·5	+5·2	+3·2	+ 0·9	+0·3	- 7·5	-4·8	-12·1	-7·7	-15·5	- 6·0	-17·1	-7·1	-14·1
10	+8·2	+8·8	+1·3	0·0	-1·8	- 8·7	-7·6	-13·4	-10·9	-16·0	- 8·0	-18·6	-8·1	-16·0
11	+5·6	+8·0	-2·2	- 1·2	-4·5	-10·0	-8·1	-14·5	-11·7	-17·8	-10·4	-18·1	-8·5	-15·1
Noon ..	+3·7	+5·7	-3·8	- 4·7	-7·3	-12·7	-10·4	-18·1	-12·4	-19·7	-12·2	-21·3	-9·1	-11·0
13	+1·2	+3·1	-5·9	- 7·7	-9·1	-15·3	-10·6	-18·2	-12·7	-19·9	-12·7	-18·7	-10·8	-14·9
14	+0·2	+2·2	-5·5	-10·2	-8·6	-18·1	-11·4	-20·4	-13·2	-19·1	-15·4	-20·9	-12·7	-14·8
15	-2·1	-0·5	-5·8	-11·0	-8·6	-17·7	-11·0	-20·0	-14·4	-20·5	-15·2	-19·4	-13·0	-14·6
16	-0·2	-2·7	-3·8	-12·3	-7·6	-18·7	-10·9	-20·0	-13·3	-19·5	-16·0	-20·4	-13·0	-15·9
17	+0·4	-2·1	-4·7	-14·2	-6·7	-18·1	-11·3	-18·7	-13·4	-18·9	-15·6	-19·3	-11·5	-16·5
18	+0·7	-1·3	-3·6	-13·8	-8·0	-18·7	-10·1	-18·6	-13·2	-17·8	-15·1	-19·1	-10·9	-16·2
19	+1·3	-0·4	-2·0	-12·0	-6·1	-16·2	- 9·2	-16·8	-11·0	-15·8	-12·7	-17·9	-10·7	-14·9
20	+2·8	+2·0	-0·9	-10·1	-5·2	-17·6	- 7·4	-16·0	-10·4	-15·6	-11·1	-19·0	-10·4	-16·2
21	+4·0	+1·6	-1·9	- 9·4	-3·4	-16·0	- 5·9	-15·1	- 9·0	-14·1	-10·4	-17·8	- 9·6	-14·9
22	+4·0	+2·8	-0·7	- 9·0	-1·9	-17·0	- 4·3	-13·3	- 7·1	-14·6	- 8·9	-17·4	-10·0	-13·4
23	+5·5	+2·7	+0·4	- 6·3	-1·6	-15·8	- 4·3	-14·0	- 6·5	-15·4	- 8·2	-17·1	- 8·6	-13·8
Mean ...	+4·6	+3·3	0·0	- 5·8	-2·7	-13·9	- 5·8	-15·0	- 9·1	-16·5	- 9·8	-18·4	- 9·8	-15·7

V.

North and East Components of the Wind at Kurrachee in the year 1874.

miles per hour).

August.		September.		October.		November.		December.		October to March.		April to September.		Year.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
- 8·5	-19·9	-2·1	-14·0	+ 0·5	- 6·8	+3·8	- 2·0	+7·1	+1·7	+3·0	- 4·2	- 6·4	-16·0	-1·7	-10·1
- 9·3	-19·6	-1·8	-13·9	+ 0·5	- 6·3	+4·7	- 0·7	+7·3	+1·7	+3·6	- 3·2	- 6·1	-15·7	-1·2	- 9·4
- 8·7	-21·1	-1·5	-13·6	+ 1·0	- 5·1	+5·3	- 0·4	+7·7	+1·4	+4·2	- 2·9	- 5·9	-16·4	-0·8	- 9·6
- 8·3	-20·4	-1·5	-13·0	+ 2·4	- 3·7	+5·5	+ 0·6	+8·2	+2·4	+4·8	- 1·0	- 5·6	-16·1	-0·4	- 9·0
- 7·5	-20·1	-0·3	-12·9	+ 3·4	- 3·3	+5·2	+ 1·8	+8·2	+3·2	+5·3	- 1·0	- 5·0	-16·1	+0·1	- 8·5
- 6·5	-20·5	-0·4	-13·0	+ 3·1	- 2·0	+5·8	+ 2·5	+7·9	+4·4	+5·1	- 0·2	- 4·4	-16·1	+0·3	- 8·1
- 5·7	-20·1	-0·5	-14·1	+ 3·0	- 1·6	+6·3	+ 3·2	+8·4	+4·5	+5·5	+ 0·5	- 3·8	-15·7	+0·8	- 7·6
- 7·8	-21·0	-0·2	-15·5	+ 2·7	- 1·8	+5·4	+ 4·3	+8·6	+4·8	+5·5	+ 0·8	- 4·5	-16·0	+0·5	- 7·7
- 7·2	-21·0	-1·0	-15·5	+ 3·1	- 1·9	+4·8	+ 3·6	+8·4	+5·1	+5·4	+ 0·8	- 5·0	-16·2	+0·2	- 7·7
- 6·2	-19·5	-2·3	-18·1	+ 2·4	- 3·0	+4·2	+ 2·3	+8·3	+4·7	+4·5	+ 0·4	- 5·7	-16·1	-0·6	- 7·8
- 7·2	-20·0	-3·2	-17·7	- 0·8	- 5·0	+1·3	+ 0·7	+7·8	+5·3	+2·7	+ 0·2	- 7·5	-16·9	-2·4	- 8·3
- 7·2	-19·9	-5·7	-19·0	- 5·5	- 7·2	-2·6	- 1·8	+5·2	+5·4	-0·7	- 1·1	- 8·6	-17·4	-4·6	- 9·2
- 7·4	-19·1	-6·1	-18·6	- 7·1	- 9·3	-6·7	- 3·8	+1·9	+3·9	-3·2	- 3·5	-11·3	-18·5	-7·2	-11·0
- 9·0	-18·3	-6·5	-18·7	- 8·6	-10·8	-8·6	- 5·5	-1·0	+1·6	-5·3	- 5·8	-10·4	-18·1	-7·8	-11·9
-10·5	-21·0	-7·9	-19·1	-10·3	-13·4	-9·0	- 8·1	-1·4	+0·4	-5·8	- 7·9	-11·8	-19·2	-8·8	-13·5
-11·7	-21·1	-7·8	-17·6	-10·3	-13·9	-8·2	-11·0	-2·0	-2·9	-6·2	- 9·5	-12·2	-18·9	-9·2	-14·2
-12·3	-21·1	-8·1	-16·7	-10·7	-15·6	-7·7	-12·6	-2·4	-4·5	-5·4	-11·1	-12·3	-18·9	-8·8	-15·0
-11·7	-19·3	-7·8	-15·5	- 8·3	-15·6	-6·2	-12·6	-0·7	-4·8	-4·4	-11·2	-11·9	-18·0	-8·1	-14·6
-12·1	-19·5	-6·5	-14·1	- 7·6	-14·8	-4·6	-11·1	+1·0	-4·3	-3·7	-10·7	-11·3	-17·5	-7·5	-14·1
-12·2	-18·4	-5·4	-12·6	- 6·4	-12·6	-3·0	- 9·9	+2·3	-2·4	-2·3	- 8·9	-10·2	-16·1	-6·2	-12·5
-11·2	-18·1	-4·9	-11·8	- 4·6	-10·0	-2·1	- 7·2	+2·8	+0·2	-1·2	- 7·1	- 9·2	-16·1	-5·2	-11·6
-11·1	-18·3	-4·3	-12·6	- 3·1	- 7·8	-1·2	- 6·9	+3·2	+0·4	-0·4	- 6·3	- 8·4	-15·5	-4·4	-10·9
- 8·1	-19·2	-3·5	-13·6	- 0·4	- 7·0	+1·8	- 3·9	+5·2	-0·2	+1·3	- 5·7	- 7·0	-15·2	-2·8	-10·4
- 7·8	-21·4	-2·5	-13·0	+ 0·1	- 7·3	+2·1	- 3·3	+6·7	+1·2	+2·2	- 4·8	- 6·3	-15·8	-2·0	-10·3
- 9·0	-19·9	-3·8	-15·2	- 2·6	- 7·7	-0·2	- 3·4	+4·7	+1·4	+0·6	- 4·3	- 7·9	-16·8	-3·6	-10·6

TABLE

Monthly, Half-yearly, and Yearly Means of the Hourly and Daily Values of the

(Velocity in

Hour.	January.		February.		March.		April.		May.		June.		July.	
	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
Midnight	+3·0	− 5·6	+5·1	−2·0	−1·1	−10·3	− 1·1	−15·6	− 3·4	−17·6	− 7·1	−21·9	− 9·6	−18·6
1	+5·1	− 5·0	+6·8	−0·3	+0·2	−10·4	− 1·0	−15·5	− 3·4	−16·8	− 6·3	−20·9	−10·8	−19·7
2	+5·3	− 3·3	+8·4	+0·8	+0·5	−10·1	− 0·9	−16·3	− 3·5	−19·2	− 6·6	−22·1	−10·1	−18·6
3	+6·4	− 2·4	+8·2	+1·5	+0·3	−10·3	− 1·3	−15·6	− 4·2	−16·9	− 6·0	−20·4	− 9·7	−19·1
4	+6·1	− 0·7	+8·1	+2·2	−0·1	− 9·7	− 1·2	−14·8	− 3·7	−17·9	− 5·7	−21·0	− 8·6	−19·5
5	+6·4	+ 0·1	+7·4	+3·8	+0·5	− 9·7	− 1·6	−13·6	− 2·3	−17·1	− 3·6	−19·2	− 8·7	−17·7
6	+6·6	+ 1·2	+7·6	+4·2	+0·8	− 9·1	− 0·5	−12·0	− 2·9	−16·3	− 4·8	−19·8	−10·0	−18·1
7	+6·4	+ 1·9	+7·9	+4·0	+0·9	− 8·4	− 0·6	−12·8	− 2·8	− 17·7	− 4·3	−20·2	−11·0	−18·4
8	+6·3	+ 2·0	+9·1	+3·2	+0·7	− 9·2	− 1·9	−13·2	− 4·3	−17·0	− 3·8	−20·6	− 9·4	−18·7
9	+5·4	+ 1·3	+9·2	+3·5	−0·9	−11·1	− 4·1	−14·7	− 5·6	−17·5	− 5·8	−21·5	−11·4	−18·9
10	+4·5	+ 0·2	+9·2	+4·6	−5·9	−12·2	− 7·0	−16·0	− 7·9	−18·9	− 6·3	−21·3	−10·3	−18·8
11	+1·2	− 1·3	+5·8	+3·0	−8·2	−14·9	− 7·6	−16·3	− 9·1	−19·5	− 7·5	−21·9	−10·4	−20·1
Noon ...	0·0	− 1·7	+2·3	+1·9	−9·5	−16·4	−10·5	−18·1	−10·3	−19·8	− 9·7	−21·8	−11·1	−19·3
13	−3·2	− 4·4	+0·8	−0·5	−10·1	−17·3	−10·6	−19·2	−10·5	−21·1	−11·8	−23·1	−11·1	−19·2
14	−3·7	− 6·9	−1·1	−3·5	−9·8	−19·2	−10·7	−20·6	−11·9	−23·4	−13·9	−23·1	−12·6	−20·2
15	−5·1	− 8·0	−4·1	−5·2	−10·4	−18·3	−10·2	−20·9	−11·7	−22·4	−13·8	−23·2	−12·7	−19·8
16	−5·3	−10·4	−4·8	−6·5	−8·6	−17·8	−10·2	−20·5	−11·0	−23·0	−15·3	−24·8	−12·6	−19·7
17	−4·4	−10·3	−4·1	−5·9	−8·8	−16·3	− 8·8	−19·4	− 9·4	−22·7	−13·7	−21·5	−12·4	−18·8
18	−3·6	−11·3	−2·2	−7·1	−7·4	−16·0	− 8·5	−19·4	− 8·2	−21·8	−13·6	−22·0	−12·4	−18·4
19	−2·7	−10·0	−1·7	−6·2	−7·9	−15·3	− 7·6	−18·6	− 5·2	− 18·5	−13·0	−21·5	−13·1	−18·2
20	−1·7	−10·1	+0·5	−4·9	−6·0	−13·8	− 6·7	−16·6	− 4·4	−17·9	−12·7	−21·2	−12·4	−17·2
21	−1·6	− 9·3	+2·3	−3·8	−4·1	−13·1	− 5·7	−17·2	− 3·5	−16·0	−11·5	−21·0	−10·4	−16·0
22	−0·5	− 8·2	+2·6	−2·5	−3·5	−10·9	− 4·4	−16·7	− 4·8	−17·3	−10·3	−19·5	− 9·8	−17·4
23	+0·9	− 7·8	+3·8	−2·4	−2·9	−10·4	− 2·0	−15·5	− 3·8	−17·2	− 9·1	−21·6	− 9·2	−17·1
Mean ...	+1·3	− 4·6	+3·6	−0·8	−4·2	−12·9	− 5·2	−16·6	− 6·2	−18·9	− 9·0	−21·5	−10·8	−18·6

VI.

North and East Components of the Wind at Kurrachee in the year 1875.
miles per hour).

August.		September.		October.		November.		December.		October to March.		April to September.		Year.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
—9·6	—20·4	—5·5	—15·3	—1·4	—6·1	+3·8	—1·7	+8·2	+1·9	+2·9	—4·0	—6·0	—18·2	—1·5	—11·1
—8·9	—21·4	—5·1	—13·5	—1·0	—6·3	+4·0	—1·6	+8·3	+3·1	+3·9	—3·4	—5·9	—18·0	—1·0	—10·7
—7·6	—21·3	—6·0	—13·6	—0·7	—5·5	+5·5	—1·1	+9·4	+3·4	+4·7	—2·6	—5·8	—18·5	—0·5	—10·5
—9·2	—21·0	—5·4	—13·7	—0·7	—5·9	+5·1	—1·2	+9·8	+3·8	+4·8	—2·4	—6·0	—17·8	—0·6	—10·1
—9·2	—20·7	—4·8	—14·4	—0·9	—5·3	+4·4	—0·2	+9·8	+3·3	+4·6	—1·7	—5·5	—18·0	—0·4	—9·
—10·2	—20·7	—4·2	—13·9	—0·6	—5·3	+5·3	0·0	+9·1	+4·7	+4·7	—1·1	—5·1	—17·0	—0·2	—9·
—8·0	—20·3	—4·4	—13·9	+0·1	—4·8	+5·8	+0·1	+9·5	+5·0	+5·1	—0·6	—5·1	—16·7	0·0	—8·
—8·0	—20·3	—4·5	—14·6	+0·4	—4·8	+5·5	+2·5	+9·8	+5·8	+5·1	+0·2	—5·2	—17·3	0·0	—8·
—8·4	—20·3	—4·8	—14·1	+0·4	—5·1	+4·7	+3·5	+9·6	+6·3	+5·1	+0·1	—5·4	—17·3	—0·1	—8·
—8·9	—20·4	—7·0	—15·2	—2·0	—7·1	+3·8	+1·8	+9·4	+6·6	+4·1	—0·8	—7·1	—18·0	—1·5	—9·
—10·0	—20·8	—7·0	—16·3	—5·4	—8·0	—0·7	+2·0	+5·1	+6·8	+1·1	—1·1	—8·1	—18·7	—3·5	—9·
—10·7	—19·9	—7·8	—15·3	—7·2	—9·6	—3·6	+0·4	+3·0	+6·0	—1·5	—2·7	—8·8	—18·8	—5·1	—10·
—12·2	—19·3	—9·4	—15·7	—7·6	—11·0	—5·5	—0·8	+1·7	+4·4	—3·1	—3·9	—10·5	—19·0	—6·8	—11·
—13·1	—19·9	—10·4	—15·6	—9·8	—12·5	—7·5	—2·4	—0·3	+4·0	—5·0	—5·5	—11·2	—19·7	—8·1	—12·
—15·0	—20·9	—11·3	—16·2	—10·8	—13·1	—8·3	—4·8	—0·9	+1·3	—5·8	—7·7	—12·6	—20·7	—9·2	—14·
—15·5	—20·4	—10·7	—16·4	—11·3	—15·0	—8·5	—7·1	—1·3	—1·4	—6·8	—9·2	—12·4	—20·5	—9·6	—14·
—15·4	—19·5	—11·5	—16·1	—10·4	—13·8	—7·0	—9·5	—0·9	—2·5	—6·2	—10·1	—12·7	—20·6	—9·4	—15·
—15·1	—19·7	—9·2	—14·2	—9·9	—12·8	—4·9	—9·6	+0·1	—2·5	—5·3	—9·6	—11·4	—19·4	—8·3	—14·
—14·5	—19·0	—8·0	—13·1	—8·5	—12·8	—2·5	—8·3	+1·9	—2·4	—3·7	—9·6	—10·9	—18·9	—7·3	—14·
—13·5	—19·4	—8·1	—13·4	—7·2	—10·9	—2·8	—6·0	+3·5	—1·1	—3·1	—8·2	—8·4	—18·3	—5·7	—13·
—12·5	—18·1	—6·6	—11·7	—5·8	—8·0	—1·1	—3·1	+3·9	—0·8	—1·7	—6·8	—9·2	—17·1	—5·4	—11·
—11·3	—18·3	—6·0	—12·2	—3·9	—7·0	—0·4	—3·2	+4·4	+0·5	—0·5	—6·0	—8·1	—16·8	—4·3	—11·
—10·4	—19·1	—5·1	—13·2	—2·8	—6·7	+2·5	—2·2	+5·1	+1·2	+0·6	—4·9	—7·5	—17·2	—3·4	—11·
—11·3	—19·7	—5·2	—13·0	—1·3	—6·8	+2·5	—0·7	+7·3	+1·7	+1·7	—4·4	—6·8	—17·3	—2·5	—10·
—11·2	—20·0	—7·0	—14·4	—4·5	—8·5	0·0	—2·2	+5·2	+2·5	+0·2	—4·4	—8·2	—18·3	—4·0	—11·

TABLE

Monthly, Half-yearly, and Yearly Means of the Hourly and Daily Values of the

(*Velocity in*

Hour.	January.		February.		March.		April.		May.		June.		July.	
	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
Midnight	+4·91	—1·24	+4·07	— 4·47	—0·30	—12·87	— 2·20	—14·33	— 4·77	—16·13	— 7·96	—19·23	—10·13	—18·60
1	+5·94	—1·07	+5·14	— 3·10	+0·67	—12·07	— 1·93	—15·23	— 4·53	—16·03	— 7·26	—18·80	—11·00	—19·04
2	+6·80	—0·10	+6·07	— 2·60	+0·84	—12·34	— 1·26	—15·20	— 5·03	—16·60	— 8·06	—19·97	—10·03	—18·54
3	+7·37	—0·04	+6·20	— 2·07	+1·10	—11·57	— 1·43	—15·26	— 3·73	—15·80	— 6·80	—18·93	—10·50	—19·90
4	+7·51	+0·80	+6·80	— 1·00	+0·97	—10·70	— 1·10	—14·33	— 3·70	—15·10	— 6·50	—19·63	— 9·50	—19·41
5	+7·70	+1·10	+5·90	— 0·20	+1·20	—10·44	— 0·66	—13·33	— 3·50	—15·30	— 5·40	—19·17	— 9·10	—19·9[illegible]
6	+7·70	+2·13	+6·14	+ 0·80	+1·60	— 9·74	— 0·46	—11·60	— 3·60	—14·93	— 5·53	—18·97	— 8·80	—19·17
7	+7·80	+2·23	+6·30	+ 1·10	+1·84	— 8·97	— 0·70	—12·10	— 3·63	—15·83	— 5·23	—18·83	— 9·67	—19·24
8	+7·77	+2·70	+6·17	+ 1·16	+1·24	— 9·44	— 1·80	—12·20	— 4·97	—15·50	— 5·33	—19·20	— 8·93	—19·34
9	+7·50	+2·70	+5·00	+ 1·43	—0·63	—10·27	— 3·93	—13·70	— 6·10	—16·13	— 6·83	—19·73	— 9·80	—19·20
10	+7·57	+3·43	+3·67	+ 1·00	—3·60	—11·70	— 6·50	—13·83	— 8·40	—17·10	— 7·86	—20·13	—10·20	—19·24
11	+3·77	+2·40	—0·44	— 0·50	—6·26	—13·60	— 7·70	—15·80	— 9·77	—18·27	— 9·50	—19·83	—10·80	—19·40
Noon ...	+1·74	+0·46	—2·20	— 8·34	—8·30	—15·54	—10·00	—18·06	—10·47	—19·07	—11·33	—21·00	—11·37	—19·07
13	—1·26	—1·80	—4·00	— 5·74	—9·43	—17·17	—10·50	—19·26	—11·30	—20·30	—12·30	—20·97	—12·60	—19·44
14	—2·30	—3·40	—4·70	— 8·37	—8·83	—19·40	—10·66	—20·46	—11·97	—20·57	—14·10	—21·37	—13·43	—19·57
15	—4·20	—5·77	—5·23	— 9·97	—9·33	—19·24	—10·60	—20·90	—12·53	—20·93	—14·46	—21·40	—14·33	—19·67
16	—3·46	—7·54	—4·40	—10·80	—8·06	—18·74	—10·13	—20·36	—11·53	—20·70	—15·40	—22·13	—14·23	—19·67
17	—2·46	—7·57	—3·96	—11·14	—7·83	—18·14	—10·16	—20·30	— 4·30	—20·53	—14·73	—20·73	—14·13	—19·97
18	—1·16	—7·27	—2·03	—10·80	—7·13	—17·30	— 9·30	—19·46	—10·07	—19·40	—14·40	—20·53	—13·40	—18·44
19	—0·33	—6·40	—1·06	— 9·80	—6·03	—16·14	— 8·60	—18·26	— 7·77	—17·57	—12·83	—19·83	—13·93	—18·37
20	+0·67	—4·64	—0·10	— 7·84	—4·76	—15·27	— 6·96	—16·73	— 6·97	—16·50	—11·96	—19·53	—12·27	—17·77
21	+1·70	—4·57	+0·70	— 7·10	—3·20	—14·64	— 6·03	—16·40	— 5·93	—15·23	—10·96	—19·88	—11·57	—17·67
22	+1·67	—3·27	+1·70	— 6·37	—2·13	—14·24	— 4·36	—15·10	— 5·17	—15·43	— 9·93	—18·83	—11·37	—17·04
23	+2·40	—2·84	+2·90	— 4·94	—1·56	—14·07	— 3·60	—15·40	— 4·87	—16·13	— 9·66	—19·53	—10·20	—17·80
Mean ...	+3·17	—1·67	+1·67	— 4·37	—3·23	—13·87	— 5·43	—16·13	— 7·10	—17·30	— 9·73	—19·90	—11·30	—18·97

VII

North and East Components of the Wind at Kurrachee in the three years 1873 to 1875.

miles per hour.)

August.		September.		October.		November.		December.		October to March.		April to September.		Year.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
− 8·33	−19·00	−4·07	−15·17	0·00	− 6·20	+4·57	−1·66	+7·30	+1·83	+3·43	− 4·10	− 6·24	−17·06	−1·40	−10·58
− 8·10	−19·90	−3·60	−14·93	+0·27	− 5·93	+4·87	−0·76	+7·67	+2·36	+4·09	− 3·43	− 6·07	−17·32	−0·99	−10·38
− 7·23	−20·40	−3·44	−14·43	+0·47	− 5·26	+5·77	−0·40	+8·24	+2·33	+4·69	− 3·07	− 5·68	−17·52	−0·49	−10·29
− 8·43	−19·80	−2·97	−14·67	+0·87	− 4·73	+6·00	+0·20	+8·94	+3·00	+5·08	− 2·54	− 5·65	−17·39	−0·28	− 9·96
− 7·63	−19·10	−2·17	−14·70	+1·37	− 4·10	+5·67	+1·00	+9·00	+3·23	+5·22	− 1·80	− 5·10	−17·05	+0·07	− 9·42
− 7·90	−19·73	−2·04	−14·73	+1·63	− 3·33	+6·37	+1·57	+8·57	+4·60	+5·23	− 1·05	− 4·77	−17·03	+0·24	− 9·04
− 6·13	−19·07	−2·04	−14·53	+1·90	− 2·76	+6·87	+2·20	+8·84	+5·00	+5·50	− 0·40	− 4·43	−16·37	+0·54	− 8·39
− 7·06	−19·80	−1·90	−15·57	+1·83	− 2·86	+6·70	+4·77	+9·14	+5·36	+5·60	+ 0·27	− 4·70	−16·89	+0·45	− 8·31
− 7·20	−19·50	−2·50	−15·20	+2·03	− 3·53	+5·90	+3·64	+8·87	+5·73	+5·33	+ 0·11	− 5·12	−16·82	+0·11	− 8·35
− 7·63	−19·83	−4·50	−17·20	+0·43	− 5·00	+5·30	+2·74	+8·57	+6·03	+4·36	− 0·40	− 6·47	−17·63	−1·05	− 9·01
− 8·56	−19·70	−5·10	−17·33	−2·73	− 6·80	+1·53	+2·40	+6·60	+6·43	+1·39	− 0·88	− 7·77	−17·88	−3·18	− 9·38
− 9·20	−19·83	−6·54	−18·03	−6·20	− 8·90	−2·00	+0·84	+4·20	+5·76	−1·01	− 2·34	− 8·92	−18·52	−4·96	−10·43
− 9·86	−19·53	−7·07	−18·07	−7·67	−10·70	−5·60	−1·03	+1·44	+4·20	−3·43	− 4·33	−10·02	−19·05	−6·72	−11·69
−11·30	−19·50	−7·80	−18·20	−9·07	−12·13	−7·33	−2·53	−0·70	+2·36	−5·30	− 6·17	−10·97	−19·61	−8·13	−12·89
−12·30	−20·50	−9·04	−18·37	−9·80	−13·90	−7·33	−5·30	−1·13	+0·33	−5·68	− 8·34	−11·92	−20·14	−8·79	−14·24
−12·83	−20·70	−8·57	−17·63	−10·00	−14·80	−7·20	−7·86	−2·03	−2·34	−6·33	−10·00	−12·22	−20·20	−9·27	−15·10
−12·93	−19·93	−9·24	−17·00	− 9·50	−15·16	−6·03	−9·56	−1·73	−3·57	−5·53	−10·88	−12·24	−19·96	−8·88	−15·42
−12·83	−20·07	−8·60	−15·77	− 8·13	−14·16	−4·17	−9·13	−0·30	−3·70	−4·48	−10·64	−11·96	−19·56	−8·21	−15·10
−12·33	−19·00	−7·50	−14·43	− 6·90	−13·28	−2·37	−8·00	+1·14	−2·84	−3·07	− 9·91	−11·17	−18·54	−7·12	−14·22
−12·13	−18·43	−7·04	−13·83	− 5·67	−11·53	−1·53	−6·40	+2·44	−1·14	−2·03	− 8·57	−10·38	−17·71	−6·20	−13·14
−10·76	−17·60	−6·30	−12·60	− 3·97	− 9·10	−0·33	−4·16	+2·97	+0·20	−0·89	− 6·80	− 9·20	−16·77	−5·04	−11·79
−10·40	−17·90	−5·90	−13·60	− 2·40	− 7·53	+0·70	−4·10	+3·74	+0·80	+0·17	− 6·21	− 8·47	−16·77	−4·14	−11·49
− 8·56	−18·13	−4·87	−13·97	− 1·10	− 7·10	+2·67	−2·40	+5·20	+0·56	+1·37	− 5·47	− 7·38	−16·41	−3·00	−10·94
− 8·76	−19·57	−4·44	−14·20	− 0·20	− 7·03	+3·30	−1·53	+6·77	+1·50	+2·52	− 4·75	− 6·75	−17·10	−2·11	−10·93
− 9·53	−19·40	−5·27	−15·60	− 3·00	− 8·13	+0·90	−1·93	+4·77	+2·03	+0·71	− 4·66	− 8·06	−17·88	−3·67	−11·27

TABLE

Mean diurnal variation of the North and East Components of the Wind at Kurrachee

(Velocity in

Hour.	January.		February.		March.		April.		May.		June.		July.	
	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
Midnight	+1·77	+0·43	+2·40	−0·10	+2·93	+1·00	+3·23	+1·80	+2·33	+1·17	+1·77	+0·77	+1·17	+0·37
1	+2·77	+0·60	+3·47	+1·27	+3·90	+1·80	+3·50	+0·90	+2·57	+1·27	+2·47	+1·10	+0·30	−0·07
2	+3·63	+1·57	+4·40	+1·77	+4·07	+1·53	+4·17	+0·93	+3·07	+0·70	+1·67	−0·07	+1·27	+0·43
3	+4·20	+1·63	+4·53	+2·30	+4·33	+2·30	+4·00	+0·87	+3·37	+1·50	+2·93	+0·97	+0·80	−0·93
4	+4·37	+2·47	+5·13	+3·37	+4·20	+3·17	+4·33	+1·80	+3·40	+2·20	+3·23	+0·27	+1·80	−0·47
5	+4·53	+2·77	+4·23	+4·57	+4·43	+3·43	+4·77	+2·80	+3·60	+2·00	+4·33	+0·73	+2·20	−0·97
6	+4·53	+3·80	+4·47	+5·17	+4·83	+4·13	+4·97	+4·53	+3·50	+2·37	+4·20	+0·93	+2·50	−0·20
7	+4·63	+3·90	+4·63	+5·47	+5·07	+4·90	+4·73	+4·03	+3·47	+1·47	+4·50	+1·07	+1·63	−0·27
8	+4·60	+4·37	+4·50	+5·53	+4·47	+4·53	+3·63	+3·93	+2·13	+1·80	+4·40	+0·70	+2·37	−0·37
9	+4·33	+4·37	+3·33	+5·80	+2·60	+3·60	+1·50	+2·43	+1·00	+1·17	+2·90	+0·17	+1·50	−0·23
10	+3·40	+5·10	+2·00	+5·37	−0·37	+2·17	−1·07	+2·30	−1·30	+0·20	+1·87	−0·23	+1·10	−0·27
11	+0·60	+4·07	−1·23	+3·87	−3·03	+0·27	−2·27	+0·33	−2·67	−0·97	+0·23	+0·07	+0·50	−0·43
Noon ...	−1·43	+2·13	−3·87	+1·03	−5·07	−1·67	−4·57	−1·93	−3·37	−1·77	−1·60	−1·10	−0·07	+0·10
13	−4·43	−0·13	−5·67	−1·37	−6·20	−3·30	−5·07	−3·13	−4·20	−3·00	−2·57	−1·07	−1·30	−0·47
14	−5·47	−1·73	−6·37	−4·00	−5·60	−5·53	−5·23	−4·33	−4·87	−3·27	−4·37	−1·47	−2·13	−0·60
15	−7·37	−4·10	−6·90	−5·60	−6·10	−5·37	−5·17	−4·77	−5·43	−3·63	−4·73	−1·50	−3·03	−0·70
16	−6·63	−5·87	−6·07	−6·33	−4·83	−4·87	−4·70	−4·23	−4·43	−3·40	−5·67	−2·23	−2·93	−0·70
17	−5·63	−5·90	−5·63	−6·77	−4·60	−4·27	−4·73	−4·17	−4·20	−3·23	−5·00	−0·83	−2·83	−1·00
18	−4·33	−5·60	−3·70	−6·43	−3·90	−3·43	−3·87	−3·33	−2·97	−2·10	−4·67	−0·60	−2·10	+0·53
19	−3·50	−4·73	−2·73	−5·43	−2·80	−2·27	−3·17	−2·13	−0·67	−0·27	−3·10	+0·07	−2·63	+0·60
20	−2·50	−2·97	−1·57	−3·47	−1·53	−1·40	−1·53	−0·60	+0·13	+0·90	−2·23	+0·37	−0·97	+1·20
21	−1·70	−2·90	−0·97	−2·83	+0·03	−0·77	−0·60	−0·27	+1·17	+2·07	−1·23	+0·07	−0·27	+1·30
22	−1·30	−1·60	+0·03	−2·00	+1·10	−0·37	+1·07	+1·03	+1·93	+1·87	−0·20	+1·07	−0·07	+1·93
23	+0·77	−1·17	+1·23	−0·57	+1·67	+0·20	+1·83	+0·73	+2·23	+1·17	+1·07	+0·37	+1·10	+1·17

VIII.

in each month, in the winter and summer half-years, and in the whole year.

miles per hour).

August.		September.		October.		November.		December.		October to March.		April to September.		Year.	
North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.	North.	East.
+1·20	+0·40	+1·20	+0·43	+3·00	+1·93	+3·67	+0·27	+2·53	−0·20	+2·72	+0·56	+1·82	+0·82	+2·27	+0·69
+1·43	−0·50	+1·67	+0·67	+3·27	+2·20	+3·97	+1·17	+2·90	+0·33	+3·38	+1·23	+1·99	+0·56	+2·68	+0·89
+2·30	−1·00	+1·83	+1·17	+3·47	+2·87	+4·87	+1·53	+3·47	+0·30	+3·98	+1·59	+2·38	+0·36	+3·18	+0·98
+1·13	−0·40	+2·30	+0·93	+3·87	+3·40	+5·10	+2·13	+4·17	+0·97	+4·37	+2·12	+2·41	+0·49	+3·39	+1·31
+1·90	+0·80	+3·10	+0·90	+4·37	+4·03	+4·77	+2·93	+4·23	+1·20	+4·51	+2·86	+2·96	+0·83	+3·74	+1·85
+1·63	−0·33	+3·23	+0·87	+4·63	+4·80	+5·47	+3·50	+3·80	+2·57	+4·52	+3·61	+3·29	+0·85	+3·91	+2·23
+3·40	+0·33	+3·23	+1·07	+4·90	+5·37	+5·97	+4·13	+4·07	+2·97	+4·79	+4·26	+3·63	+1·51	+4·21	+2·68
+2·47	−0·40	+3·37	+0·03	+4·83	+5·27	+5·80	+6·70	+4·37	+3·33	+4·89	+4·93	+3·36	+0·99	+4·12	+2·96
+2·33	−0·10	+2·77	+0·40	+5·03	+4·60	+5·00	+5·57	+4·10	+3·70	+4·62	+4·77	+2·94	+1·06	+3·78	+2·92
+1·90	−0·43	+0·77	−1·60	+3·43	+3·13	+4·40	+4·67	+3·80	+4·00	+3·65	+4·26	+1·59	+0·25	+2·62	+2·26
+0·97	−0·30	+0·17	−1·73	+0·27	+1·33	+0·63	+4·33	+1·83	+4·40	+0·68	+3·78	+0·29	0·00	+0·80	+1·89
+0·33	−0·43	−1·27	−2·43	−3·20	−0·77	−2·90	+2·77	−0·57	+3·73	−1·72	+2·32	−0·86	−0·64	−1·29	+0·84
−0·33	+0·13	−1·80	−2·47	−4·67	−2·57	−6·50	+0·90	−3·33	+2·17	−4·14	+0·33	−1·96	−1·17	−3·05	−0·42
−1·77	−0·10	−2·53	−2·60	−6·07	−4·00	−8·23	−0·60	−5·47	+0·33	−6·01	−1·51	−2·91	−1·73	−4·46	−1·62
−2·77	−1·10	−3·77	−3·77	−6·80	−5·77	−8·23	−3·37	−5·90	−1·70	−6·39	−3·68	−3·86	−2·26	−5·12	−2·97
−3·30	−1·30	−3·30	−2·03	−7·00	−6·67	−8·10	−5·93	−6·80	−4·37	−7·04	−5·34	−4·16	−2·32	−5·60	−3·83
−3·40	−0·53	−3·97	−1·40	−6·50	−7·03	−6·93	−7·63	−6·50	−5·60	−6·24	−6·22	−4·18	−2·08	−5·21	−4·15
−3·30	−0·67	−3·33	−0·17	−5·13	−6·03	−5·07	−7·20	−5·07	−5·73	−5·19	−5·98	−3·90	−1·68	−4·54	−3·83
−2·80	+0·40	−2·23	+1·17	−3·90	−5·10	−3·27	−6·07	−3·63	−4·87	−3·79	−5·25	−3·11	−0·66	−3·45	−2·95
−2·60	+0·97	−1·77	+1·77	−2·67	−3·40	−2·43	−4·47	−2·33	−3·17	−2·74	−3·91	−2·32	+0·17	−2·53	−1·87
−1·23	+1·80	−1·03	+3·00	−0·97	−0·97	−1·23	−2·23	−1·80	−1·63	−1·60	−2·14	−1·14	+1·11	−1·37	−0·52
−0·87	+1·50	−0·63	+2·00	+0·60	+0·60	−0·20	−2·17	−1·03	−1·23	−0·54	−1·55	−0·41	+1·11	−0·47	−0·22
+0·97	+1·27	+0·40	+1·63	+1·90	+1·03	+1·77	−0·47	+0·43	−1·47	+0·66	−0·81	+0·68	+1·47	+0·67	+0·33
+0·77	−0·17	+0·83	+1·40	+2·80	+1·10	+2·40	+0·40	+2·30	−0·53	+1·81	−0·09	+1·31	+0·78	+1·56	+0·34

TABLE IX.

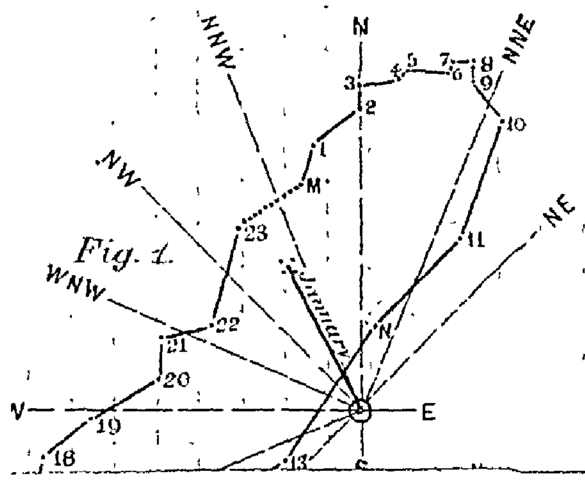
Monthly, Half-yearly, and Yearly means of the Hourly and Daily Values of the velocity of the Wind (regardless of direction) at Kurrachee, in the years 1873 to 1875.

(Velocity in miles per hour).

Hour.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	October to March.	April to September.	Year.
Midnight ...	11·1	10·3	14·5	15·9	18·1	22·2	23·2	21·5	16·3	11·1	6·9	9·2	10·5	19·5	15·0
1	11·2	10·0	13·9	16·7	17·7	21·3	23·8	22·3	16·4	11·4	7·0	9·4	10·5	19·7	16·1
2	11·2	10·2	14·1	16·2	18·1	23·0	23·0	22·2	15·8	11·0	7·1	9·6	10·5	19·7	15·1
3	11·6	10·2	13·5	16·4	17·3	21·4	24·1	22·3	15·9	10·8	7·3	10·4	10·6	19·6	15·1
4	11·2	10·2	12·4	15·7	16·5	22·0	23·3	21·8	15·8	10·7	7·3	10·5	10·4	19·2	14·8
5	11·2	9·8	12·2	14·9	16·8	21·3	23·8	22·3	15·8	10·6	8·0	10·7	10·4	19·1	14·8
6	11·3	9·3	11·7	13·5	16·4	21·4	22·8	21·0	15·4	10·6	8·1	11·0	10·3	18·4	14·4
7	11·2	9·9	11·6	14·2	17·4	21·1	22·8	22·0	16·5	10·6	8·5	11·5	10·5	19·0	14·8
8	11·6	9·9	12·0	14·4	17·3	21·2	23·5	21·7	16·4	10·7	8·1	11·5	10·6	19·1	14·9
9	12·1	10·3	13·2	16·2	18·8	22·1	24·2	22·2	19·1	11·7	7·8	11·8	11·1	20·4	15·8
10	12·0	11·5	14·9	17·8	20·2	22·8	24·4	22·4	19·3	13·3	7·5	11·5	11·8	21·1	16·5
11	12·3	11·7	16·8	18·7	21·5	22·9	24·8	22·8	20·3	15·8	8·3	11·0	12·6	21·8	17·2
Noon	12·3	12·8	19·5	21·3	22·4	25·0	24·7	22·6	20·7	17·8	9·8	11·2	13·9	22·8	18·3
13	13·1	14·4	21·0	22·6	23·9	25·2	25·4	23·3	20·7	19·4	11·7	11·5	15·2	23·5	19·3
14	13·8	15·6	22·8	23·8	24·4	26·6	25·8	24·8	20·9	21·1	12·9	11·8	16·3	24·4	20·4
15	14·7	16·5	22·7	23·9	25·0	26·8	26·4	25·2	20·0	22·2	14·0	13·0	17·2	24·5	20·9
16	15·0	16·5	21·6	23·4	24·4	27·7	26·0	24·5	19·5	21·9	14·4	12·9	17·0	24·2	20·6
17	14·2	16·8	20·9	23·4	24·2	26·2	26·5	24·7	18·6	20·4	13·4	12·4	16·3	23·9	20·1
18	13·5	15·8	19·9	22·4	22·9	25·8	24·5	23·5	17·1	19·0	12·2	11·2	15·3	22·7	19·0
19	13·2	14·6	18·4	21·0	20·5	24·8	24·8	22·9	16·3	16·9	10·8	10·3	14·0	21·7	17·9
20	13·1	13·0	17·1	19·0	18·8	24·0	23·3	21·5	14·8	14·3	8·9	9·4	12·6	20·2	16·4
21	12·2	12·3	16·2	18·4	17·5	24·1	23·1	21·9	15·3	12·6	8·3	9·1	11·8	20·0	15·9
22	11·4	11·5	15·5	16·9	17·3	22·6	22·7	21·0	15·2	11·9	7·6	9·1	11·2	19·3	15·2
23	11·3	10·6	15·1	17·1	17·7	22·7	23·0	22·2	15·5	11·8	7·2	8·8	10·8	19·7	15·2
Mean	12·3	12·2	16·3	18·5	19·8	23·5	24·2	22·6	17·4	14·5	9·3	10·8	12·6	21·0	16·3

Govt. Central Press.—No. 155 Meteor.—1-3-80.—600.

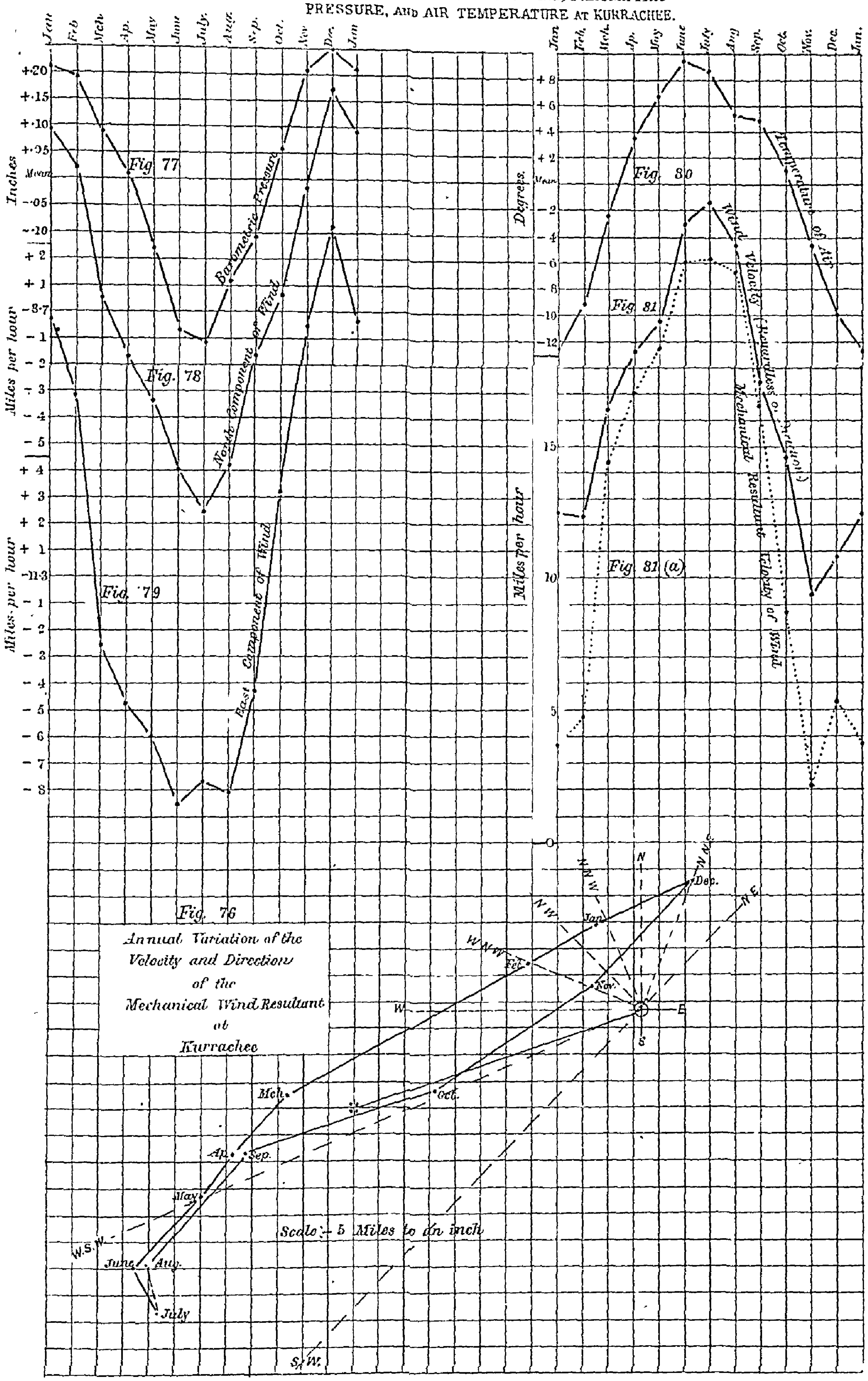
DIURNAL VARIATIONS OF THE VELOCITY AND DIR
MECHANICAL RESULTANT WIND AT KURR



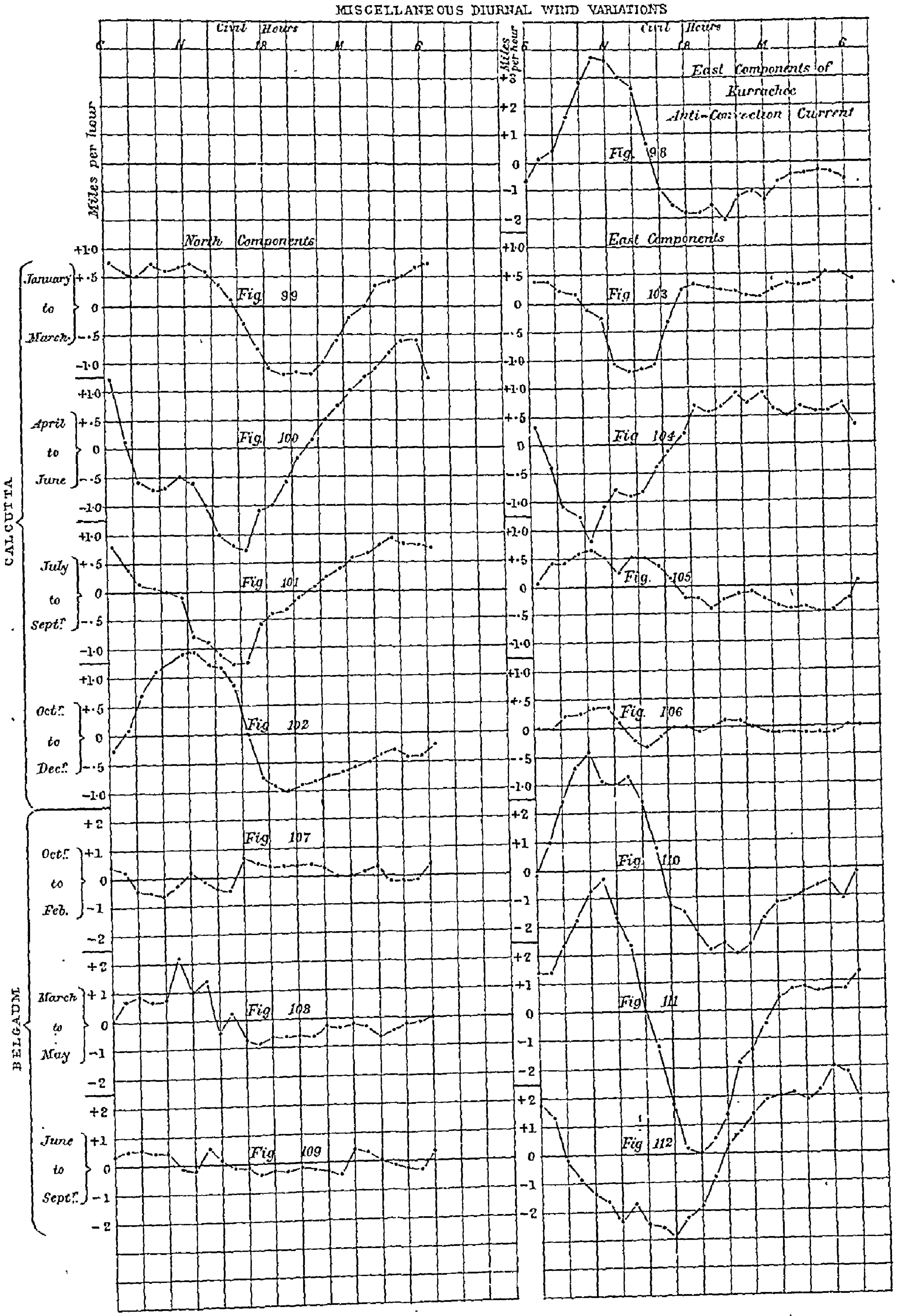
The numbers marked along the course of the curves m the hours of the civil day.

Scale :- Five Miles to an Inch.

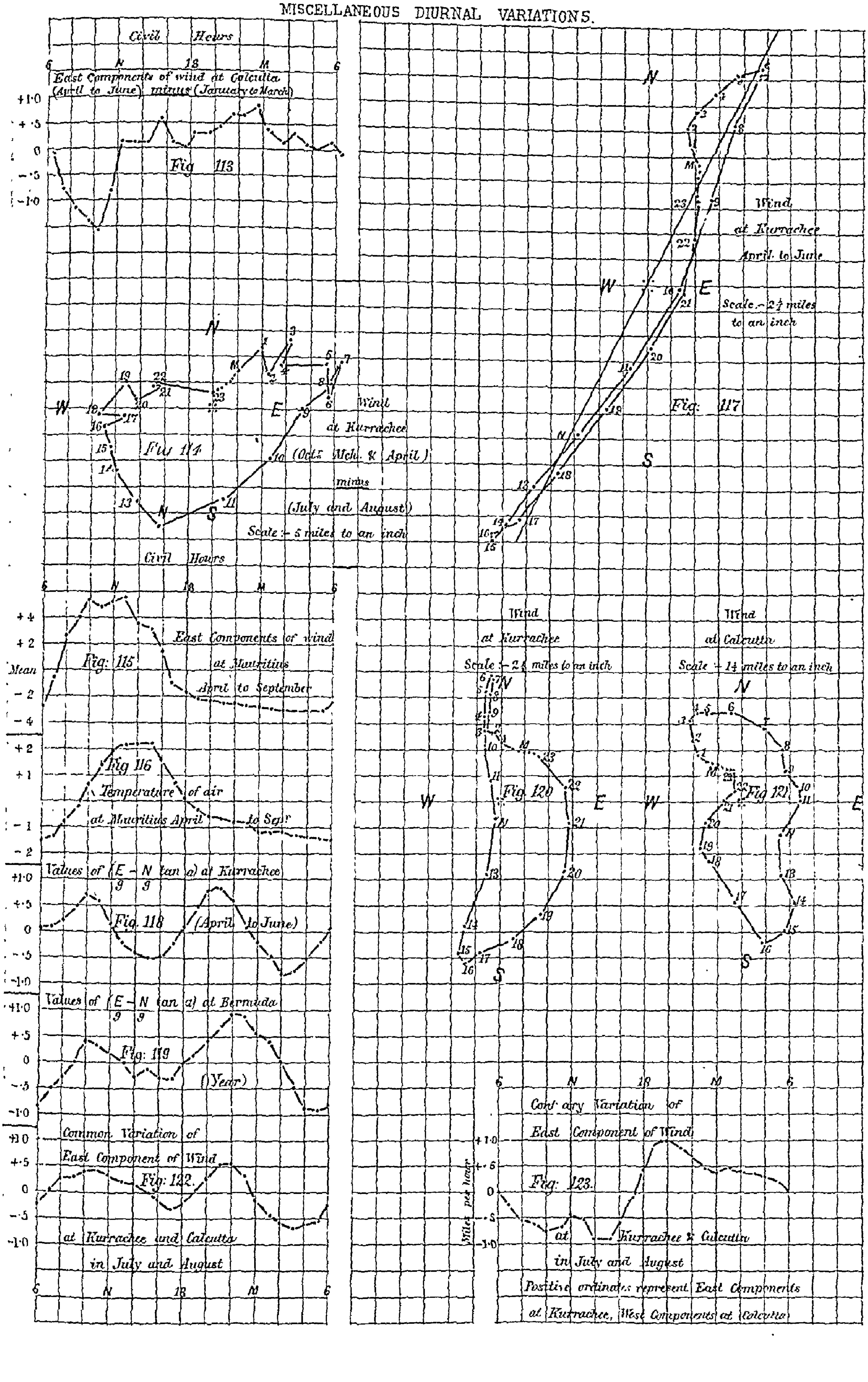
ANNUAL VARIATIONS OF THE WIND, BAROMETRIC PRESSURE, AND AIR TEMPERATURE AT KURRACHEE.



MISCELLANEOUS DIURNAL WIND VARIATIONS



MISCELLANEOUS DIURNAL VARIATIONS.



X.—Some Results of the Meteorological Observations taken at Allahabad during the ten years 1870–79, by S. A. Hill, B. Sc., *Meteorological Reporter to Government, North-Western Provinces and Oudh.*

INTRODUCTION.

When the Indian Meteorological Department was re-organized in the year 1875, it was proposed to convert the second class observatory then existing at Allahabad into a first class observatory with autographic instruments, and to remove it from the place where it was then established, at the private residence of the Meteorological Reporter, to some building belonging to Government. Towards the end of 1879 it was thought that this transfer would shortly be accomplished. Had the removal taken place, the exposure of most of the instruments would have been changed considerably, and therefore, even though no radical change had been made in the system of observation, the new observations would hardly have been comparable with the old ones. I then thought it would be well to collect and publish the more important results of the observations taken under the old system; and, though I now understand that the observatory is likely to remain in its present position some time longer, the computations for the present paper had proceeded so far when I learnt this, that I thought it would hardly be worth while to keep back the paper and go over all the calculations again, when one or two years' further data should be obtainable. Many of these calculations have involved a good deal of labour. Most of them have been worked out by myself in the first instance, and afterwards checked by my head clerk, Babu Chintamoney Ghosh, or by the assistant observer, Jadu Nath Chatterjee; but the calculations of the diurnal variation of pressure, and some others, have been made by Babu Nirdukha Coomar Ghosh, computer in the Calcutta Meteorological Office, whose assistance I have much pleasure in acknowledging.

The Allahabad observations were commenced in April 1868, under the superintendence of Captain Strahan, R.A. They were discontinued in the following August, owing to that officer's transfer to another station. In 1869, they were re-commenced under Dr. J. C. Bow, and the observatory remained in his charge until the beginning of 1872. During the greater part of this time, the instruments were kept in the "compound" of Dr. Irving's house in the old civil station, but for some months in 1871 the observatory was transferred to the Native Infantry lines. Dr. Bow was succeeded by Dr. Jones, in whose time the instruments were brought back to Dr. Irving's compound. In October 1872, Mr. Eliot took charge of the observatory, and shortly afterwards set up the instruments at the Muir College, where he was then a professor. On Mr. Eliot's appointment as Provincial Meteorological Reporter in November 1874, he established the Meteorological Office and Observatory at his own house near the Church; and when I succeeded him, on his transfer to Calcutta in 1876, his arrangements were maintained.

On account of these frequent changes of position, and of the elevations of the various places not having been accurately determined, the barometric observations taken prior to November 1874 are of little or no value; but the other observations are fairly comparable, having all been taken under nearly identical conditions. Since the last change, above mentioned, the barometers in use have been fixed with their cisterns at an elevation of 306·68 feet above Karáchi sea-level, as determined by spirit-levelling from the Great Trigonometrical Survey bench-mark at Allahabad Fort. Five years' observations of pressure, perfectly comparable with each other, are thus available for discussion.

The geographical situation of Allahabad, at the junction of the Ganges and Jumna, is well known. The latitude is about 25° 26′ North, and the longitude 81° 52′ East, from Greenwich. To the east and north-west of the station, the alluvial plain of the Ganges extends for many hundreds of miles; and on the north, the outer range of the Himálaya begins to rise above the plain at a distance of nearly 150 miles. On the south side, across the Jumna, low sandstone hills, belonging to the Vindhyan system, appear from beneath the alluvium, at a distance of 10 or 12 miles from the station. The Ganges and Jumna, for some miles near their junction, flow almost due east, and nearly parallel with each other, the distance between them varying from 2 to 3 or 3½ miles; but at the village of Pháphamau, the Ganges sweeps round, and flows southwards to join the Jumna at the Fort. For the greater part of the ten years, from 1870 to 1879, the Meteorological Observatory has been situated near the bank of this north and south reach of the Ganges, at a distance of 2½ miles from the confluence of the rivers.

In May and June, Allahabad is one of the hottest places in India, the maximum temperature in shade often rising above 115°F. During the next three months, owing to the frequent and generally abundant rainfall, it is much cooler than many stations in the Punjab, Rájputána, and Sind; but sometimes, as in 1877, the rains fail, and the months of July, August, and September may then have a mean temperature of 90°F. or more. The "cold weather," during which the mean temperature resembles that of the European summer, lasts from the beginning of November until about the middle of March.

For eight or nine months of the year, the climate is exceedingly dry. The summer or "monsoon" rains last only about three months and a half, and the cold-weather rains are always inconsiderable in quantity and sometimes altogether wanting. As a consequence of the rivers now flowing in beds far below the level of the old alluvium, the subsoil water is drained away to a very great depth, especially near the river banks; and it is probably only in years of exceptionally heavy and prolonged rainfall, that the soil gets saturated down to the permanent water level, from 60 to 70 feet below the surface. Except in the rainy season, and for a month or two afterwards, there is little or no grassy covering to the soil, which, under the intense heat of the sun, is baked nearly as hard as brick, wherever it is not shaded by trees or artificially irrigated. Near the observatory, the country is much better wooded than at a few miles distance all round, and therefore the observed humidity of the air is probably greater, and the daily range of temperature less, than in the more open parts of the neighbouring country.

TEMPERATURE.

The temperature registers for 1868 and 1869 are incomplete, but those for the ten following years have only one or two short breaks, amounting altogether to about ten days. The observations of the ten years, 1870—79, have accordingly been adopted for the discussion of the annual variation of temperature. To determine diurnal inequality, the following data are available:—

(1.) Complete sets of hourly observations taken from midnight to midnight on the 7th, 14th, 21st, and 28th of each month for about four and a half years. For the purposes of this paper, the observations of the four complete years, from November 1875 to October 1879, have been adopted; the computations for the hourly variation having been commenced before the end of 1879.

(2.) Daily extremes of temperatures for ten years, as registered by maximum and minimum thermometers.

(3.) Observations taken daily at 4 A.M., 10 A.M., 4 P.M., and 10 P.M. The 10 A.M. and 4 P.M. observations extend over the whole period of ten years, but the night observations are either wanting or of doubtful accuracy in the following months, *viz.*, May 1870 to August 1872, June 1875 and April 1876. The mean temperatures of these months at 4 A.M. have been calculated, with an error of probably not more than a tenth of a degree, by adding to the minimum temperatures, corrections proportional to the range of temperature, and varying with each month. These were determined from the observations of the same months in other years. The missing observations at 10 P.M. have been interpolated, with an almost equally small probable error, from the means of the 10 A.M., 4 P.M., and minimum observations, by the addition of similar variable corrections. The series of observations taken at equal intervals of six hours thus practically extends over ten years.

Since 1873, the temperatures at the hours of observation have been taken from a standard thermometer, No. 12491, by L. Casella. The corrections to the Kew standard, furnished with this instrument, were applied to all the readings up to May 1876, when a new set of corrections, determined by an indirect comparison with a Kew standard at Calcutta, was adopted. In August 1879, a direct comparison with another Kew standard, No. 30382, was made, and the freezing point was verified by surrounding the instrument with melting ice. The original and final corrections were—

		Original correction.	Final correction.
At	32°	+0·4°	−0·3°
„	52°	+0·4°	−0·3°
„	67°	+0·6°	−0·1°
„	82°	+0·7°	−0·2°
„	102°	+0·7°	−0·2°

The corrections determined in 1876 had intermediate values. Since the instrument was compared at the Kew Observatory, its freezing point has risen seven-tenths of a degree. What thermometers were employed in the years prior to 1873 is not known. They were probably small dry-bulb thermometers of Mason's hygrometer, as made by Casella.

The thermometers have always been exposed in a wire cage, from four to four and

a half feet above the ground, placed under a thatched shed open at the sides. In India, it is found that no other system of exposure effectually protects the instruments from radiation.

The shed in use at Allahabad is about 15 feet square in plan; the eaves are 4 feet above the ground; (up to 1876 they were a little higher;) and the roof rises in the middle to a height of 12 feet. The floor is of loose earth, and the cage is placed nearly in the middle of the shed. For several feet all round the thermometers, the ground is thus effectually shaded; and since the roof of the shed is supported on slender posts, the instruments receive little or no reflected or radiant heat from any side.

Diurnal variation.—The data for determining the diurnal inequality of temperature at Allahabad have been detailed above. In calculating the variation for each month, the process described by Mr. Blanford at page 63, (*ante*), has been followed. The sixteen sets of twenty-five hourly observations having been tabulated, the means were struck, and any small difference between the midnight observations at the beginning and end of the series was distributed so as to leave the value for noon unchanged. The mean temperatures at 4, 10, 16 and 22 hours, determined from the daily observations of ten years, were then substituted for the means at these hours given by the hourly observations, and the figures for all the other hours were altered in proportion. Table I gives the final results :—

TABLE I.

Mean hourly temperatures at Allahabad derived from 16 complete sets of hourly observations in each month, corrected by ten years' 6-hourly observations.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Midnight	54·0	58·7	68·4	78·5	84·3	85·6	82·8	81·3	79·4	71·1	60·0	52·7	71·4
1	52·8	57·6	67·2	76·3	82·9	85·4	82·4	80·9	79·0	70·5	58·9	51·9	70·5
2	51·8	56·2	66·3	74·9	82·1	84·7	81·9	80·7	78·8	69·9	58·4	51·0	69·7
3	51·1	55·3	65·4	73·8	81·4	84·5	81·3	80·2	78·7	69·3	57·7	50·1	69·1
4	50·3	54·2	64·0	73·0	80·2	84·3	80·8	79·9	78·5	68·8	56·9	49·7	68·4
5	50·0	53·6	63·2	71·9	79·6	83·9	80·6	79·4	78·1	68·6	56·8	49·4	67·9
6	49·8	53·0	62·7	71·6	80·1	84·3	80·7	79·4	77·8	68·4	56·7	49·3	67·8
7	49·8	53·9	65·0	76·3	83·9	85·5	82·0	80·2	79·2	70·6	58·3	49·6	69·5
8	52·9	59·0	71·8	83·1	90·5	89·1	83·9	82·0	81·2	75·0	63·9	54·1	73·9
9	58·4	65·1	78·2	89·2	93·9	92·4	85·6	83·5	83·9	79·1	69·1	59·7	78·2
10	63·4	70·3	83·3	94·2	97·2	95·3	87·2	85·7	85·9	83·1	74·3	65·5	82·1
11	67·2	74·6	87·2	96·9	100·6	97·9	87·9	86·6	87·5	86·9	78·4	69·3	85·1
Noon	70·2	76·8	89·1	98·1	102·0	99·3	88·4	87·3	88·8	88·1	81·4	72·6	86·8
13	72·0	79·4	90·8	100·3	104·2	100·3	88·9	87·9	89·2	88·6	82·4	74·3	88·2
14	72·7	80·0	91·6	100·7	105·0	100·8	89·7	88·2	89·3	88·8	83·0	74·7	88·7

Mean hourly temperatures at Allahabad derived from 16 complete sets of hourly observations in each month, corrected by ten years' 6-hourly observations—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
15	72·7	79·9	91·4	100·5	104·3	100·3	89·4	87·7	88·7	88·4	81·7	74·3	88·3
16	71·4	78·9	90·6	99·8	103·5	99·3	89·0	87·2	87·5	86·6	79·9	72·1	87·1
17	67·8	75·6	88·3	97·7	101·8	97·6	87·3	86·4	85·9	81·7	72·9	66·4	84·1
18	62·8	70·1	83·2	92·7	98·1	95·0	86·7	84·1	83·1	77·7	68·8	61·7	80·3
19	60·6	66·2	78·2	87·6	94·5	91·6	85·1	83·1	82·0	76·1	67·0	59·3	77·6
20	58·6	64·1	75·5	84·7	91·8	89·9	84·1	82·7	81·3	74·2	64·8	58·1	75·8
21	57·3	62·7	73·5	83·1	89·5	88·4	83·3	82·4	80·9	73·4	63·4	56·8	74·6
22	56·3	61·1	72·1	81·6	87·5	87·1	83·2	82·0	80·6	72·5	61·9	54·8	73·4
23	55·4	59·8	70·2	79·9	85·6	86·7	83·0	81·8	79·8	71·7	60·9	53·7	72·4
Means ...	59·6	65·2	76·6	86·1	91·9	91·2	84·9	83·4	82·7	77·0	67·4	59·6	77·1

These figures, when plotted out on ruled paper, give the tolerably smooth and regular curves which are printed on Plate XXIV. It has been pointed out by Mr. C. Chambers, F.R.S., in discussing the Bombay observations, that the diurnal inequality of temperature in India is not one that can be represented by a few terms of Bessel's formula of sines, and this is exemplified in the above table. There is an abrupt turn at the minimum, which occurs about sunrise; and for some hours before and after the minimum, the variation is so uniform, that it might almost be represented by a straight line.

The effect of applying the harmonic formula, unless the whole of the twelve possible terms that can be computed from hourly observations be employed, is to round off the minimum and displace it some distance in the direction of early morning. Dr. Bergsma, in the third volume of the Batavia observations, notices the same defect in Bessel's formula, as applied to temperature observations.

The formula for the mean temperature at any hour, on the average of the year, has been computed out to eight periodic terms, and is the following:—

$$
\begin{aligned}
T_n = 77^\circ{\cdot}1 &+ 9^\circ{\cdot}9234 \sin (n\ 15^\circ + 233^\circ 13') \\
&+ 2^\circ{\cdot}7473 \sin (n\ 30^\circ + 62^\circ 34') \\
&+ 0^\circ{\cdot}4272 \sin (n\ 45^\circ + 20^\circ\ 0') \\
&+ 0^\circ{\cdot}6786 \sin (n\ 60^\circ + 225^\circ 25') \\
&+ 0^\circ{\cdot}0523 \sin (n\ 75^\circ + 80^\circ 39') \\
&+ 0^\circ{\cdot}1710 \sin (n\ 90^\circ + 43^\circ\ 2') \\
&+ 0^\circ{\cdot}0307 \sin (n\ 105^\circ + 220^\circ 54') \\
&+ 0^\circ{\cdot}0764 \sin (n\ 120^\circ + 220^\circ 55')
\end{aligned}
$$

The constant co-efficients of the first two terms are the largest, and, on the whole, these constants become smaller the higher the term; but the variation is by no means regular. Neglecting all the terms above the fourth, we get the computed variations in

Table II, where the observed variations are also given for comparison. The two variations are represented together in fig. 13, Plate XXIV.

TABLE II.

Hourly variation of Temperature at Allahabad computed from the first four periodic terms of Bessel's Formula. (*Means for the whole year.*)

Hour.	Computed values.	Original values.	Difference computed − observed
Midnight	− 5·85	− 5·7	− 0·15
1	− 6·74	− 6·6	− 0·14
2	− 7·31	− 7·4	+ 0·09
3	− 7·89	− 8·0	+ 0·11
4	− 8·74	− 8·7	− 0·04
5	− 9·49	− 9·2	− 0·29
6	− 9·26	− 9·3	+ 0·04
7	− 7·26	− 7·6	+ 0·34
8	− 3·51	− 3·2	− 0·31
9	+ 1·02	+ 1·1	− 0·08
10	+ 5·09	+ 5·0	+ 0·09
11	+ 7·97	+ 8·0	− 0·03
Noon	+ 9·76	+ 9·7	+ 0·06
13	+10·92	+11·1	− 0·18
14	+11·60	+11·6	0·00
15	+11·39	+11·2	+ 0·19
16	+ 9·80	+10·0	− 0·20
17	+ 6·88	+ 7·0	− 0·12
18	+ 3·42	+ 3·2	+ 0·22
19	+ 0·47	+ 0·5	− 0·03
20	− 1·46	− 1·3	− 0·16
21	− 2·59	− 2·5	− 0·09
22	− 3·54	− 3·7	+ 0·16
23	− 4·67	− 4·7	+ 0·03

The minimum temperature, calculated from the formula by Jelinek's method of approximation, falls at 5h. 24m. A.M., and is equal to 67°·525 on the average of the year. The maximum occurs at 2h. 21m. P.M., and its value is 86°·756. The mean daily range of temperature, thus determined, is only 21°·23, which is 2°·47 less than the range given by self-registering thermometers. A standard thermometer with a large bulb is less sensitive than a smaller instrument, and for this reason the daily range indicated by it will be less. Moreover, the temperature extremes, calculated from hourly observations, are those of the times which, *on the average*, are hottest and coldest;

while the maximum and minimum thermometers record the daily extremes, at whatever instant they may occur.

By assuming that the rate of change of temperature before and after the maximum or minimum is uniform, and equal to that observed during the first complete hour before or after, we can calculate the approximate times of occurrence of the daily extremes. The times thus determined will not be exactly those of the turning points of temperature, because the assumption made is not strictly true, and the rate of change is so slow, especially before the minimum, that an error of a tenth of a degree, in the observed temperature of any hour, may give rise to an error of several minutes in the result. Table III gives the mean times of maximum and minimum for each month, thus calculated, and the 10-year means of the observations of self-registering thermometers. The mean time of sunrise at the middle of each month is given for comparison with the time of lowest temperature:—

TABLE III.

Daily Extremes of Temperature at Allahabad.

(Means of ten years' Observations).

Month.	Mean Times.						Mean Temperatures.		
	Sunrise.		Minimum.		Maximum.		Minimum.	Maximum.	Range.
	h.	m.	h.	m.	h.	m.	°	°	°
January	6	42	6	56	14	39	48·4	73·9	25·5
February	6	25	6	0	14	34	52·3	81·1	28·8
March	6	4	5	54	14	23	61·4	93·1	31·7
April	5	41	5	52	14	27	70·4	102·8	32·4
May	5	23	5	45	14	4	77·7	106·7	29 0
June	5	13	5	30	14	0	82·6	103·7	21·1
July	5	17	5	48	14	5	79·6	92·7	13·1
August	5	33	5	37	13	44	78·7	90·2	11·5
September	5	54	5	57	13	42	77·2	90·6	13·4
October	6	18	6	0	13	40	67·3	89·5	22·2
November	6	37	6	0	13	50	54·9	83·5	28·6
December	6	47	6	55	14	0	48·3	75·6	27·3
Mean	6	0	6	1	14	5	66·6	90·3	23·7

The time of minimum temperature, thus roughly determined, lies near that of sunrise in most of the months. Were continuous records of temperature available, or even observations taken at intervals of five or ten minutes, the two epochs would probably show a much closer coincidence. The maximum temperature occurs a little after 2 P.M., on the average of the year, as it does in most parts of the world. During the months from January to May, when strong westerly winds blow in the day-time, the maximum falls after 2 P.M.; and in August, September, October, and November, when the winds are frequently easterly, or calm, the hottest time of the day is between 1 and 2 P.M.

The daily range of temperature varies from month to month, inversely with the humidity of the air and the extent of cloudy sky. It has two maxima, in April and November, and two minima, in August and January.

Annual variation.—The mean temperature of each month is given at the foot of Table I. The figures represent the true mean temperature of the month, as nearly as it

can at present be determined. The means of the four equidistant observations (4, 10, 16, and 22 hours) are invariably too high; they could not, indeed, be justly expected to equal the true diurnal means, unless the variation were of such a character as to be fairly represented by the first two terms of a harmonic formula. For stations in the North-Western Provinces and other parts of India, however, the average of four observations at equal intervals of six hours has hitherto been assumed to be the true daily mean; and until the hourly observations of other stations have been worked up, it will be better to retain this assumption as regards Allahabad. Otherwise, the temperature observations of Allahabad would not be comparable with those of neighbouring places. The crude means given in the next two tables may be reduced to true means, by subtracting the following quantities for each month:—

January	0·8°	July	0·2°
February	0·9°	August	0·3°
March	0·9°	September	0·4°
April	1·0°	October	0·7°
May	0·3°	November	0·9°
June	0·3°	December[1]	0·9°

TABLE IV.

Mean Monthly and Annual Temperatures at Allahabad.

(Means of Four Observations).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1870	61·0	66·7	76·1	84·1	93·0	89·3	83·7	81·6	81·9	78·2	67·3	60·0	76·9
1871	59·5	67·5	76·3	84·4	87·3	84·9	82·2	81·6	80·7	79·1	70·9	61·5	76·3
1872	61·8	65·2	79·6	84·8	91·9	88·0	83·8	82·4	82·0	77·7	69·1	62·9	77·5
1873	61·8	68·3	78·0	88·8	91·7	96·9	84·5	84·3	83·7	76·3	68·7	60·4	78·6
1874	59·8	65·4	75·6	90·5	95·3	85·6	83·8	82·3	83·0	77·5	64·7	60·0	77·0
1875	59·4	65·3	80·9	89·1	90·2	90·6	84·2	82·3	82·6	76·7	67·5	61·5	77·5
1876	60·3	65·9	76·4	88·1	94·1	95·7	85·5	84·3	82·7	74·5	66·4	58·2	77·7
1877	60·2	59·8	74·6	83·1	91·1	93·1	90·3	90·5	89·0	79·7	73·7	63·1	79·0
1878	58·5	69·0	79·2	87·6	89·0	98·7	89·1	84·9	83·5	81·2	70·1	60·0	79·2
1879	61·3	68·1	78·3	91·0	97·3	91·9	83·6	82·5	81·6	76·4	64·0	57·6	77·8
Mean	60·4	66·1	77·5	87·2	92·1	91·5	85·1	83·7	83·1	77·7	68·3	60·5	77·8
Probable error	0·7	1·7	1·4	1·8	2·0	3·2	1·7	1·8	1·5	1·3	2·0	1·2	0·63
Mean computed by Bessel's Formula	60·2	66·7	77·0	87·3	92·6	90·5	85·8	83·6	82·9	78·0	68·3	60·6	...
Difference, observed — computed...	+0·2	−0·6	+0·5	−0·2	−0·5	+1·0	−0·7	+0·1	+0·2	−0·3	0·0	−0·1	..

[1] These are the corrections derived from Table I. If we take the original hourly observations of 16 days in each month, the corrections deduced from them will be—

January	0·8°	July	0·3°
February	0·8°	August	0·4°
March	1·0°	September	0·4°
April	1·0°	October	0·8°
May	0·2°	November	0·9°
June	0·2°	December	1·0°

The corrections given in the text vary more regularly from month to month, and are to be preferred.

The table indicates that, on the average, the temperature is lowest about the beginning of January, and highest in the latter half of May; while, during the rainy months of July, August, and September, it varies little. In the column of annual means, the decennial inequality of temperature observed at tropical stations is also fairly marked. The increase of temperature from the coldest year, 1871, up to the hottest, 1878, would be fairly uniform, but for the interposition of the year 1873, which was nearly as hot as 1877. At the foot of the table, the mean temperature of each month, calculated by Bessel's formula, is given. The months are not calendar months however, but mean months of 30·44 days each. The mean temperature of the n_{th} month after the middle of January may be computed by the formula.

$$\begin{aligned} T_n = 77{\cdot}8^\circ &+ 14^\circ{\cdot}581 \; sin \; (n \; 30^\circ + 291^\circ \; 21') \\ &+ \; 4{\cdot}825 \; sin \; (n \; 60^\circ + 266^\circ \; 34') \\ &+ \; 1{\cdot}026 \; sin \; (n \; 90^\circ + \; 49^\circ \; 36') \end{aligned}$$

The residues in the last line of Table IV indicate that the low temperature of February and the sudden rise from February to March are not adequately represented by the formula; neither are the high temperature of the first half of June and the rapid decrease at the commencement of the rains. Variations of a shorter period than two months, like the considerable fall of temperature at the end of July and beginning of August, are also, of course, not represented. The formula indicates that the lowest temperature of the year falls on the 6th of January, and that the hottest day is the 20th of May.

The hottest and coldest days of a normal year may be better determined, by computing the average temperature of each individual day, and clearing the results of minor inequalities, that would probably disappear if the period of observation were extended, by some process of smoothing. This has been done in a way suggested by Dr. Galle of Breslau, and published at page 379 of the "*Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie*," Band XIV. If the mean temperatures of several successive days, as given by observation, be a, b, c, d, &c., and the smoothed means, *a, b, c, d, &c.*, then

$$d = \tfrac{1}{40} \, (a + 4b + 9c + 12d + 9e + 4f + g),$$
$$e = \tfrac{1}{40} \, (b + 4c + 9d + 12e + 9f + 4g + h),$$

and so on.

The result is practically identical with that given by the more tedious process of taking the mean for every pair of consecutive days six times over. In either case, the rationale of the process is to use the observed temperatures of a whole week, to calculate the probable temperature of the middle day, the several days being assigned weights proportional to the probabilities, that whatever causes produce a certain temperature on the middle day, will produce an equal temperature on the other days also.

In Table V, the normal temperature of each day of the year, calculated in this way from the observations of ten years, is given :—

TABLE V.

Normal Daily Temperature at Allahabad.

(From ten years' 6-hourly observations).

DATE.	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1st	60·5	63·1	71·8	84·2	90·1	93·5	86·0	82·5	83·9	82·3	72·9	64·0
2nd	60·6	63·1	72·1	83·8	89·7	93·8	86·0	82·5	83·7	82·2	72·3	63·7
3rd	60·2	62·8	72·5	83·5	89·6	94·1	86·1	82·7	83·5	82·1	71·8	63·2
4th	59·7	62·8	72·6	83·4	89·7	94·3	86·0	83·0	83·1	81·8	71·6	62·8
5th	59·3	62·8	72·7	83·6	89·8	94·1	85·7	83·2	82·7	81·2	71·7	62·5
6th	59·0	63·1	73·0	84·1	90·4	93·9	85·6	83·4	82·5	80·4	71·8	62·3
7th	58·6	63·7	73·2	84·8	90·8	93·9	85·5	83·6	82·5	79·5	71·6	62·2
8th	58·4	64·5	73·6	85·6	91·2	94·2	85·5	83·7	82·6	79·0	71·3	62·0
9th	58·4	65·1	74·2	86·3	91·5	94·5	85·4	83·4	82·7	78·5	70·4	61·6
10th	58·8	65·3	74·9	86·9	91·5	94·2	85·2	83·2	82·8	78·3	69·7	61·0
11th	59·2	65·2	75·6	87·4	91·4	93·6	85·0	83·3	83·0	78·4	69·3	60·2
12th	59·5	65·1	76·5	87·7	91·2	93·4	84·9	83·7	83·2	78·5	69·2	59·5
13th	59·6	65·0	77·4	87·5	91·2	93·7	84·9	84·1	83·3	78·6	69·1	59·3
14th	59·9	65·0	78·1	87·1	91·5	93·8	85·0	84·5	83·4	78·7	69·0	59·3
15th	60·5	64·9	78·2	86·7	91·9	93·4	85·1	84·6	83·6	78·7	68·7	59·4
16th	61·0	64·6	77·8	86·5	92·3	92·9	85·2	84·5	83·9	78·6	68·3	59·5
17th	61·2	64·7	77·1	86·7	92·5	92·5	85·3	84·1	84·0	78·3	67·9	59·6
18th	61·1	65·2	76·6	86·8	92·6	92·3	85·5	83·7	83·9	78·0	67·6	59·7
19th	61·0	65·7	76·7	87·3	92·5	91·9	85·6	83·7	83·7	77·8	67·3	59·7
20th	60·8	67·3	77·5	87·9	92·4	91·1	85·5	83·7	83·5	77·0	67·2	59·5
21st	60·8	68·3	78·5	88·6	92·5	90·7	85·2	83·6	83·3	76·4	67·0	59·3
22nd	61·1	69·6	79·6	89·1	92·8	89·1	85·0	83·6	83·2	75·9	66·6	59·1
23rd	61·2	70·1	80·4	89·2	93·3	88·4	85·0	83·6	83·1	75·3	66·1	59·2
24th	61·2	70·1	81·1	89·2	93·8	87·9	85·1	83·8	82·9	74·9	65·6	59·5
25th	60·9	70·2	81·5	89·4	94·5	87·6	85·0	83·9	82·4	74·5	65·0	59·8
26th	60·6	70·5	82·0	89·7	94·3	87·4	84·8	83·9	82·1	74·1	64·6	59·9
27th	60·5	71·0	82·6	90·0	94·2	87·2	84·5	83·9	82·0	73·9	64·3	59·8
28th	60·9	71·5	83·2	90·1	93·9	86·8	84·2	83·9	82·1	73·7	64·2	59·7
29th	61·3	..	83·8	90·2	93·6	86·4	83·6	84·1	82·3	73·7	64·2	59·6
30th	62·3	...	84·3	90·3	93·5	86·2	82·8	84·1	82·4	73·6	64·1	59·7
31st	62·8	...	84·5	.	93·5	..	82·7	84·0	...	73·4	...	60·1
Mean	60·4	66·1	77·5	87·1	92·1	91·6	85·1	83·7	83·0	77·7	68·4	60·5
Mean of 1st 10 days	59·4	63·6	73·1	84·6	90·4	94·0	85·7	83·1	83·0	80·5	71·5	62·5
„ of 2nd 10 „	60·4	65·3	77·1	87·2	92·0	92·9	85·2	84·0	83·5	78·3	68·4	59·6
„ of remaining days	61·2	70·2	82·0	89·6	93·6	87·8	84·4	83·9	82·6	74·5	65·2	59·6

The coldest day in the normal year is the 8th of January; but on the 22nd of December, the temperature is only 0·7° higher. The warmer interval between these dates coincides with the cloudy weather of the so-called "Christmas Rains." A table of normal daily rainfall is given below, and on comparing it with Table V, it will be seen that, in January, February, and March, a warm period precedes or accompanies each fall of rain, and a few colder days follow it. In the hot season, the conditions are somewhat different. Every heavy fall of rain cools the air, at first by contact and afterwards by evaporation, as in the cold weather, but before the rain comes down the clouds lower the temperature by cutting off the direct rays of the sun.

The highest normal daily temperature, 94·5°, is reached on the 25th of May. The showers which often, though not always, fall about the beginning of June, (the *chhoti barsát*) lower the mean temperature a little; but on the 9th of June it again attains the maximum. In years when the rains are late, the temperature goes on increasing up to the summer solstice; but, as soon as rain begins to fall, the air becomes rapidly cooler. Sometimes, the monsoon rains set in as early as the 10th of June; but more usually they do not begin until the 15th or 20th. The most rapid decrease of temperature occurs between the 21st and 23rd of June, when the normal daily rainfall is about a quarter of an inch. By the beginning of July, the normal temperature has fallen 8·5°, and the daily rainfall at that time is nearly half an inch. Throughout the rainy season, when the rainfall slackens or ceases, the temperature rises. This is especially noticeable at the middle and end of August and the middle of September. On the other hand, there is a very remarkable lowering of the temperature at the end of July and beginning of August, owing to the heavy rainfall about that time. The most important of these, at first sight anomalous variations of temperature, recur nearly every year. The regularity of their occurrence was first noticed by Mr. Eliot in his Report on the Meteorology of the North-Western Provinces for 1874. He also noticed a diminution of temperature in the first ten days of March, very decidedly marked at the sub-Himalayan stations, but hardly observable at Agra and Benares, which is due to a few days of stormy weather with rain that occur at that time of the year. This cool period does not appear at Allahabad any more than at Benares.

In Mr. Eliot's tables, the months were broken up into ten-day periods, and the means for these were laid down in the form of curves. In fig. 14 of Plate XXIV, the normal temperatures of Allahabad for ten-day periods, (the figures at the foot of Table V) are represented by the uneven line, while the smooth curve represents the mean temperature calculated by Bessel's formula.

The normal daily temperature is above the average of the year from the 21st of March to the 19th of October, and below it all the rest of the year, except on the 14th and 15th of March. The temperature of the coldest day is 19·4° below the mean, and that of the hottest day only 16·7° above it. Though the days when the temperature is below the average, thus number only 150 out of 365, the cold season is very cold, considering the high temperature of the rest of the year.

Variability of temperature.—The "variability" of the elements of meteorological observation has been taken by different writers to mean very different things. The true

[illegible] frequency as well as the magnitude of the deviations from the mean, is to calculate the probable error of the mean by the usual formula—

$$e \quad 0{\cdot}6745 \sqrt{\frac{\Sigma(a^2)}{n-1}}$$

where $\Sigma(a^2)$ stands for the sum of the squares of the individual variations from the mean, and n for the number of observations. In Table IV the probable errors of the means for each month and for the whole year are given. The probable error of the annual mean is 0·63° F., that is, in the majority of years, the mean temperature will not depart more than 0·63° from its normal value. In January, the probable error is less than any other month, and in the first half of the year it goes on increasing up to June, when it amounts to 2·3°. The probable errors of the means for the rainy months are higher than might be expected, because of the high temperature of the dry year 1877.

The variability of temperature, during the ten years, may be illustrated in a different way by the following table:—

Highest maximum temperature	...	...	119·8° on the 19th June 1878.
Lowest minimum „	...	...	36·0° „ 9th January 1878.
Highest daily mean „	...	...	104·5° „ 20th June 1878.
Lowest daily mean „	...	...	50·0° „ 13th January 1874.
Highest monthly mean „	...	...	98·7° in June 1878.
Lowest monthly mean „	...	...	57·6° „ December 1879.
Greatest range in a month	...	...	57·7° „ March 1878.
Highest annual mean	...	...	79·2° „ 1878.
Lowest annual mean	...	...	76·3° „ 1871.
Greatest range in a year	..	...	83·8° „ 1878.

The hottest year of the ten, 1878, was the year in which the greatest extremes of temperature were observed.

PRESSURE.

The barometers, in use since November 1874, have been kept in a room belonging to the Meteorological Reporter's residence, the height of the mercury in the cisterns being 306·68 feet above mean sea-level at Karáchi. From the commencement of the pressure observations, till the 21st of January 1876, a large standard barometer, No. $\frac{2}{1832}$ by Adie, was used. It became unserviceable, on account of the mercury leaking out of the cistern, and was replaced by a small standard, No. 753, by Casella. This continued in use up to the 10th September 1878, when it was accidently damaged in cleaning. Since the 1st of January 1879, the observations have been taken by means of a similar instrument, No. 627, Casella, and, in the interval, a Newman's standard, No. 43, kept as an alternative instrument, was used. The errors of all these ins[illegible]ments, ex-

cept the first, were determined by direct comparison with the Calcutta standard. The large Adie was compared with No. 753, Casella, and No. 43, Newman, while it was still in good order, and thus its error to the Calcutta standard was ascertained indirectly. Corrections for these errors were applied to all the readings, *viz.*—

No. $\frac{2}{1865}$,	Adie,	—·010	inch.
No. 753,	Casella,	+·005	„
No. 43,	Newman,	—·003	„
No. 627,	Casella,	+·002	„.

The large standards by Newman and Adie, having tubes more than half an inch in diameter, are less affected by capillarity and friction, than the smaller Casella standards with tubes only about 0·4 inch wide. For this reason, the daily range measured by the smaller instruments should be somewhat less than that given by the larger ones, if other circumstances were the same.

The diminution of range from this cause, in the years after 1875, has, however, been little if anything. The mean daily range between 10 A.M. and 4 P.M. was ·111″ in 1875, ·112″ in 1876, ·115″ in 1877, ·118″ in 1878, and ·112″ in 1879. In the dry and hot years, 1877 and 1878, when the range of temperature was excessive, the barometric range was greatest, and in the other years it was nearly constant. In 1875, the year of heaviest rainfall, greatest humidity and lowest temperature, the range was least of all, though that was the year in which the largest barometer was employed. We may therefore take the whole series of observations since November 1874 to be strictly comparable with each other.

Diurnal variation.—The observations, adopted for calculating the diurnal inequality of pressure, are the following:—

(1.) Four complete sets of hourly observations for each month, from November 1875 to October 1879, inclusive, or sixteen sets for each month of the year.

(2.) Five years' daily observations at 4, 10, 16 and 22 hours, from November 1874 to October 1879.[1]

The method according to which these have been dealt with is the same as that described by Mr. Blanford in discussing the Hazáribágh observations; (see page 176). The mean pressure at each hour, and its variation from the mean of the day, are given in Table VI:—

[1]. The observations for 4 A.M. and 10 P.M. in June 1875 and April 1876 have been interpolated by means of range-factors derived from the observations of these months in other years.

TABLE VI.

Mean hourly pressures and hourly variations of pressure at Allahabad, corrected to the 5-Year Means of Six-hourly Readings. (Means of Sixteen Series of hourly readings in each month.)

Hours	January Mean	January Difference	February Mean	February Difference	March Mean	March Difference	April Mean	April Difference	May Mean	May Difference	June Mean	June Difference
Midnight	29 726	0	29 683	+ 003	29 559	+ 003	29 433	− 002	29 330	− 002	29 210	+ 006
1	721	− 005	676	− 004	519	− 037	425	− 010	315	− 017	204	0
2	715	− 011	666	− 014	512	− 044	419	− 016	311	− 021	199	− 005
3	708	− 018	661	− 019	535	− 021	412	− 023	315	− 017	194	− 010
4	705	− 021	659	− 021	533	− 023	420	− 015	327	− 005	199	− 005
5	710	− 016	668	− 012	545	− 011	434	− 001	348	+ 016	209	+ 005
6	725	− 001	683	+ 003	566	+ 010	455	+ 020	361	+ 029	226	+ 022
7	744	+ 018	704	+ 024	587	+ 031	472	+ 037	381	+ 049	247	+ 043
8	766	+ 040	725	+ 045	613	+ 057	494	+ 059	392	+ 060	256	+ 052
9	789	+ 063	741	+ 061	626	+ 070	505	+ 070	396	+ 064	260	+ 056
10	795	+ 069	746	+ 066	629	+ 073	503	+ 068	394	+ 062	259	+ 055
11	777	+ 051	738	+ 058	618	+ 062	491	+ 056	386	+ 054	250	+ 046
Noon	750	+ 024	711	+ 031	595	+ 039	473	+ 038	368	+ 036	230	+ 026
13	720	− 006	681	+ 001	563	+ 007	433	− 002	344	+ 012	207	+ 003
14	697	− 029	656	− 024	536	− 020	415	− 020	317	− 015	192	− 012
15	684	− 042	637	− 043	514	− 042	391	− 044	295	− 037	161	− 043
16	683	− 043	632	− 048	505	− 051	376	− 059	270	− 062	145	− 059
17	686	− 040	627	− 053	502	− 054	372	− 063	265	− 067	138	− 066
18	693	− 033	641	− 039	507	− 049	380	− 055	274	− 058	146	− 058
19	708	− 018	654	− 026	519	− 037	396	− 039	285	− 047	163	− 041
20	723	− 003	671	− 009	535	− 021	418	− 017	302	− 030	181	− 023
21	732	+ 006	688	+ 008	550	− 006	434	− 001	317	− 015	194	− 010
22	735	+ 009	687	+ 007	563	+ 007	442	+ 007	339	+ 007	212	+ 008
23	732	+ 006	686	+ 006	565	+ 009	443	+ 008	337	+ 005	212	+ 008
Means	726		680		556		435		332		204	

Hours	July Mean	July Difference	August Mean	August Difference	September Mean	September Difference	October Mean	October Difference	November Mean	November Difference	December Mean	December Difference	Year Mean	Year Difference
Midnight	29 216	+ 004	29 300	+ 012	29 384	+ 011	29 560	+ 001	29 677	− 004	743	− 002	29 484	+ 002
1	205	− 007	291	+ 003	375	+ 002	549	− 010	672	− 009	737	− 008	476	− 006
2	198	− 014	279	− 009	364	− 009	542	− 017	665	− 016	730	− 015	468	− 014
3	194	− 018	275	− 013	354	− 019	537	− 022	661	− 020	726	− 019	464	− 018
4	198	− 014	276	− 012	355	− 018	537	− 022	660	− 021	723	− 022	465	− 017
5	206	− 006	282	− 006	366	− 007	550	− 009	668	− 013	731	− 014	476	− 006
6	221	+ 009	295	+ 007	383	+ 010	566	+ 007	692	+ 011	745	0	492	+ 010
7	235	+ 023	311	+ 023	401	+ 028	589	+ 030	714	+ 033	766	+ 021	512	+ 030
8	248	+ 036	320	+ 032	419	+ 046	609	+ 050	732	+ 051	788	+ 043	529	+ 047
9	254	+ 042	332	+ 044	427	+ 054	620	+ 061	747	+ 066	814	+ 069	542	+ 060
10	255	+ 043	337	+ 049	428	+ 055	619	+ 060	745	+ 064	815	+ 070	543	+ 061
11	248	+ 036	329	+ 041	418	+ 045	605	+ 046	730	+ 049	798	+ 053	532	+ 050
Noon	240	+ 028	313	+ 025	398	+ 025	579	+ 020	698	+ 017	767	+ 022	509	+ 027
13	221	+ 009	291	+ 003	370	− 003	550	− 009	665	− 016	735	− 010	481	− 001
14	197	− 015	267	− 021	343	− 030	529	− 030	643	− 038	713	− 032	458	− 024
15	181	− 031	245	− 043	323	− 050	514	− 045	632	− 049	703	− 042	469	− 013
16	165	− 047	231	− 057	313	− 060	540	− 019	666	− 015	699	− 046	430	− 052
17	161	− 051	226	− 062	317	− 056	546	− 013	644	− 037	703	− 042	429	− 053
18	172	− 040	269	− 019	329	− 044	524	− 035	653	− 028	715	− 030	438	− 044
19	187	− 025	268	− 020	348	− 025	540	− 019	666	− 015	726	− 019	453	− 029
20	206	− 006	278	− 010	371	− 002	562	+ 003	680	− 001	739	− 006	471	− 011
21	221	+ 009	303	+ 015	385	+ 012	569	+ 010	687	+ 006	749	+ 004	485	+ 003
22	231	+ 019	313	+ 025	391	+ 018	570	+ 011	688	+ 007	754	+ 009	493	+ 011
23	229	+ 017	310	+ 022	388	+ 015	567	+ 008	685	+ 004	750	+ 005	491	+ 009
Means	212		288		373		559		681		745		482	

The next two tables exhibit the rectangular co-ordinates of the constants of the periodic formula for the diurnal variation in each month, and the constant co-efficients computed from them. The constant of the fourth periodical term is less than ·002° for every month, except December and January.

TABLE VII.

Rectangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at Allahabad computed from Table VI.

Months.	$U \sin u$	$U' \cos u'$	$U'' \sin u''$	$U'' \cos u''$	$U''' \sin u'''$	$U''' \cos u'''$	$U'''' \sin u''''$	$U'''' \cos u''''$
January	—·01165	+·02120	+·01532	—·03172	—·00019	+·00778	—·00246	—·00209
February	—·01353	+·02503	+·01795	—·03199	—·00112	+·00420	—·00104	—·00065
March	—·01859	+·03106	+·02050	—·03217	+·00193	+·00256	—·00017	—·00115
April	—·01654	+·03501	+·01739	—·03347	—·00020	—·00119	—·00096	—·00065
May	—·01898	+·04057	+·01560	—·02804	—·00077	—·00670	+·00121	—·00137
June	—·01095	+·03729	+·01741	—·02549	+·00038	—·00340	—·00029	+·00180
July	—·00810	+·02080	+·01614	—·02588	—·00196	—·00459	—·00033	+·00029
August	—·00306	+·02525	+·02050	—·02858	—·00269	—·00346	—·00067	—·00058
September	—·00532	+·02668	+·01725	—·03343	—·00126	+·00069	+·00038	+·00108
October	—·01020	+·02326	+·01132	—·03463	+·00032	+·00332	—·00142	—.00029
November	—·01085	+·02419	+·00821	—·03523	+·00159	+·00740	—·00079	—·00137
December	—·01265	+·02276	+·01358	—·03342	+·00055	+·00812	—·00246	—·00281
Year	—·01178	+·02785	+·01598	—·03110	—.00028	+·00121	—·00088	—·00079

TABLE VIII.

Constant co-efficients of the periodical formula computed from Table VII.

Months.	Mean.[1]	U'	u'	U''	u''	U'''	u'''	U''''	u''''
January	29·727	·02419	331° 13′	·03523	154° 13′	·00778	358° 36′	·00323	229° 39′
February	·679	·02845	331° 36′	·03668	150° 42′	·00435	345° 4′	·00123	237° 59′
March	·556	·03620	329° 6′	·03814	147° 30′	·00321	37° 1′	·00116	188° 25′
April	·433	·03872	334° 43′	·03773	152° 33′	·00121	189° 32′	·00116	235° 54′
May	·330	·04479	334° 56′	·03209	150° 55′	·00674	186° 33′	·00183	138° 33′
June	·201	·03886	343° 38′	·03087	145° 40′	·00342	173° 37′	·00182	350° 51
July	·210	·02232	338° 43′	·03050	148° 3′	·00199	203° 7′	·00044	311° 19′
August	·277	·02544	353° 5′	·03517	144° 2	·00438	217° 52′	·00089	229° 7′
September	·370	·02721	348° 43′	·03762	152° 42′	·00144	298° 42′	·00114	19° 23′
October	·557	·02540	336° 19′	·03643	161° 54′	·00334	5° 30′	·00145	258° 27′
November	·671	·02651	335° 51′	·03617	166° 52′	·00757	12° 8′	·00158	209° 58′
December	·736	·02604	330° 56′	·03607	157° 52′	·00814	3° 53′	·00373	221° 12′
Year	29·479	·03024	337° 4′	·03497	152° 48′	·00124	346° 58′	·00118	228° 5′

[1] These values are the means of six-hourly observations for the five calendar years 1875—79.

Tables IX, X, and XI give the computed hourly variations from the mean of each month and of the whole year, the epochs of the semi-diurnal maxima and minima, and the variations at these epochs from the mean of the day:—

TABLE IX.

Hourly variation of pressure at Allahabad computed with the constants of Table VIII.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Midnight	+·0010	+·0024	+·0036	−·0003	−·0030	+·0065	+·0057	+·0140	+·0111	·0000	−·0018	−·0010	+·0030
1	−·0060	−·0059	−·0061	−·0106	−·0142	+·0007	−·0050	+·0020	+·0007	−·0097	−·0099	−·0088	−·0063
2	−·0121	−·0137	−·0165	−·0184	−·0211	−·0059	−·0151	−·0082	−·0102	−·0178	−·0171	−·0149	−·0142
3	−·0168	−·0191	−·0228	−·0201	−·0181	−·0093	−·0185	−·0127	−·0173	−·0219	−·0209	−·0184	−·0177
4	−·0194	−·0196	−·0213	−·0144	−·0051	−·0058	−·0146	−·0112	−·0170	−·0200	−·0191	−·0192	−·0153
5	−·0161	−·0130	−·0109	−·0012	+·0139	+·0058	−·0045	−·0039	−·0076	−·0103	−·0097	−·0147	−·0060
6	−·0044	+·0018	+·0078	+·0178	+·0329	+·0230	+·0090	+·0076	+·0091	+·0073	+·0078	−·0014	+·0098
7	+·0175	+·0232	+·0316	+·0395	+·0482	+·0407	+·0232	+·0214	+·0287	+·0295	+·0310	+·0211	+·0295
8	+·0432	+·0460	+·0548	+·0586	+·0585	+·0533	+·0348	+·0350	+·0455	+·0502	+·0536	+·0476	+·0484
9	+·0628	+·0625	+·0707	+·0699	+·0636	+·0578	+·0420	+·0450	+·0552	+·0623	+·0672	+·0670	+·0607
10	+·0666	+·0662	+·0734	+·0693	+·0627	+·0541	+·0432	+·0476	+·0552	+·0605	+·0651	+·0698	+·0613
11	+·0520	+·0549	+·0611	+·0562	+·0539	+·0436	+·0376	+·0412	+·0444	+·0147	+·0163	+·0532	+·0493
Noon	+·0246	+·0316	+·0370	+·0331	+·0366	+·0277	+·0259	+·0256	+·0243	+·0198	+·0166	+·0232	+·0272
13	−·0052	+·0029	+·0073	+·0052	+·0120	+·0067	+·0081	+·0034	−·0021	−·0073	−·0143	−·0084	+·0007
14	−·0287	−·0237	−·0205	−·0224	−·0155	−·0175	−·0127	−·0212	−·0290	−·0300	−·0373	−·0319	−·0240
15	−·0416	−·0429	−·0412	−·0449	−·0403	−·0411	−·0327	−·0431	−·0503	−·0145	−·0479	−·0434	−·0427
16	−·0448	−·0516	−·0527	−·0590	−·0579	−·0586	−·0166	−·0572	−·0604	−·0494	−·0469	−·0448	−·0523
17	−·0406	−·0500	−·0549	−·0622	−·0653	−·0618	−·0197	−·0597	−·0572	−·0447	−·0381	−·0399	−·0524
18	−·0312	−·0398	−·0492	−·0546	−·0617	−·0584	−·0118	−·0500	−·0429	−·0327	−·0258	−·0308	−·0436
19	−·0183	−·0216	−·0372	−·0381	−·0484	−·0425	−·0250	−·0300	−·0229	−·0165	−·0132	−·0187	−·0283
20	−·0048	−·0086	−·0214	−·0182	−·0291	−·0231	−·0054	−·0064	−·0035	−·0008	−·0021	−·0056	−·0110
21	+·0056	+·0035	−·0059	−·0009	−·0100	−·0062	+·0104	+·0136	+·0108	+·0097	+·0018	+·0018	+·0033
22	+·0096	+·0094	+·0050	+·0081	+·0027	+·0017	+·0176	+·0240	+·0178	+·0129	+·0073	+·0090	+·0107
23	+·0074	+·0081	+·0083	+·0076	+·0047	+·0086	+·0150	+·0232	+·0176	+·0087	+·0017	+·0062	+·0099

TABLE X.

Diurnal epochs of Minimum and Maximum pressure at Allahabad.

Months.	1st Minimum.		1st Maximum.		2nd Minimum.		2nd Maximum.	
	h.	m.	h.	m.	h.	m.	h.	m.
January	4	5	9	43	15	53	22	6
February	3	36	9	45	16	20	22	19
March	3	21	9	41	16	45	22	54
April	2	45	9	28	16	48	22	26
May	2	14	9	22	17	10	22	40
June	3	3	9	2	16	59	23	7
July	2	58	9	41	16	48	22	14
August	3	14	9	49	16	43	22	25
September	3	28	9	29	16	15	22	27
October	3	14	9	22	16	0	21	53
November	3	14	9	23	15	23	21	58
December	3	43	9	39	15	39	22	0
Year	3	7	9	34	16	30	22	24

TABLE XI.

Mean monthly and annual values of the diurnal maxima and minima of the pressure variation, at the above epochs.

Months.	1st Minimum	1st Maximum.	2nd Minimum.	2nd Maximum.
January	—·0194	+·0675	—·0449	+·0097
February	—·0201	+·0667	—·0522	+·0097
March	—·0232	+·0741	—·0552	+·0084
April	—·0204	+·0713	—·0625	+·0090
May	—·0214	+·0641	—·0654	+·0052
June	—·0093	+·0578	—·0648	+·0086
July	— 0185	+·0135	—·0502	+·0178
August	—·0129	+·0478	—·0604	+·0250
September	—·0183	+·0565	—·0609	+·0185
October	—·0220	+·0633	—·0494	+·0129
November	—·0211	+·0684	—·0488	+·0073
December	—·0194	+·0711	—·0153	+·0090
Year	—·0178	+·0627	—·0535	+·0114

The most striking feature of the diurnal variation of pressure at Allahabad, especially in the hot-weather months, is its "continental" character. The night oscillation, which, over tropical seas, is nearly equal to that of the day, becomes almost obliterated, while the change of pressure between 9 or 10 A.M. and 4 P.M. is much greater than it is near the sea. At Allahabad, in May, the fall of pressure from the evening maximum to the morning minimum is only ·0266 inch, while the corresponding change between the forenoon and the afternoon is ·1295 inch, or nearly five times as great. On account of the small amplitude of the night oscillation, the morning minimum, in the hot-weather months, is thrown back to between 2 and 3 A.M., while the evening maximum occurs near 11 P.M. These features of the pressure variation are illustrated in the first thirteen curves of Plate XXV.

At Calcutta, the ratio of the amplitude of the semi-diurnal to that of the diurnal oscillation of pressure ($U'' \div U'$) is equal to 1·47 on the average of the whole year. At Bombay, on the coast, it is 2·07, while at Allahabad it is only 1·15. The maximum monthly value of this ratio at Bombay is 5·58 in July, and the minimum, 1·39 in April. At Calcutta, its greatest and least values are 1·77 in July and 1·19 in May. The monthly values of the ratio at Allahabad are—

January	... 1·46	July	... 1·37
February	... 1·34	August	... 1·38
March	... 1·05	September	... 1·35
April	... 0·97	October	... 1·43
May	... 0·72	November	... 1·37
June	... 0·80	December	... 1·39

During the hot weather, from the middle of March to the commencement of the rains, the value of this ratio is less than unity, while in the other months of the year it has a nearly constant value of about 1·40. The character of the diurnal variation of pressure at Allahabad, in these months, is therefore markedly different from that observed at coast stations, and approximates to the kind of variation observed at typical continental stations, such as Yarkand. The ratio $U'' \div U'$ calculated from Dr. Scully's observations at that station[1] is 1·14 for the winter months, November to February; 0·67 for the three spring months, March to May; and only 0·43 in the hot dry months of June and July. In each of the five months, from March to July, the morning minimum occurs about 2 A.M.

When the hourly observations of stations in India lying further inland than Allahabad—for example, those of Agra, Roorkee, and Lahore—are worked out, it will be interesting to observe whether the "continental" character of the daily variation of the barometer increases regularly with distance from the sea or not.

Annual variation.—For the discussion of the annual inequality of pressure, the observations of the five calendar years, 1875-79, have been taken. The means of four equidistant observations have been adopted as daily means. These are identical with the mean of the 24 hours on the average of the whole year, and the greatest difference in any month is ·003 inch.

---

[1] See page 64, Vol. I.

At stations in Tropical India, the height of the barometer is subject to an inequality of ten-yearly period, as was pointed out by Mr. F. Chambers in *Nature*, Vol. XVIII, page 567. Mr. Blanford has also shown (*Nature*, Vol. XXI, page 477) that a similar inequality is observable in other parts of the world, though in Northern Asia the phase of it is nearly opposite to that observed in India. It might, therefore, be supposed that five years would be too short a period of observation to give the mean height of the barometer, at an Indian station, with any close approach to accuracy. The decennial inequality of pressure, observed in Southern India, appears, however, to be considerably modified north of the tropic, and perhaps converted into one having two maxima and two minima in a period of ten or eleven years. Thus, at Roorkee, the annual mean pressure has reached a maximum three times since 1864, namely, in 1865, 1871, and 1877, the mean pressures of these years having been 28·917, 28·913, and 28·919 inches respectively. The lowest pressures of the intermediate years were 28·863 inches in 1870 and 28·858 inches in 1875. The mean pressure of the last five years, at Roorkee, was only ·001 inch below that of the sixteen years 1864—79. At Benares, a station much nearer to Allahabad, the mean pressure of the five years was ·008 inch lower than that of twelve years; and the greatest difference, in any month, was ·017 inch in October. The monthly mean pressures at Allahabad, derived from five years' observations, have therefore, probably, a maximum error of ·02 inch; and, in most of the months, the error is perhaps under ·01 inch.

In Table XII, the observed monthly and annual means of pressure are shown together with the pressure for each month, calculated by Bessel's formula.—

TABLE XII.

Mean Monthly and Annual Pressure at Allahabad.

(*Means of 4 observations*).

Years.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1875	29·667	29·681	29·499	29·392	29·329	29·164	29·187	29·286	29·367	29·551	29·708	29·751	29·465
1876	·681	·626	·541	·389	·300	·199	·153	·293	·385	·605	·670	·787	·469
1877	·795	·736	·585	·506	·369	·236	·236	·260	·400	·601	·678	·733	·511
1878	·771	·704	·599	·478	·380	·198	·236	·285	·337	·482	·615	·693	·482
1879	·723	·646	·554	·402	·274	·210	·210	·263	·359	·516	·686	·717	·468
Mean	29·727	29·679	29·556	29·433	29·330	29·201	29·210	29·277	29·370	29·557	29·671	29·736	29·479
Probable error	·037	·028	·027	·037	·030	·018	·026	·0[illegible]0	·017	·034	·024	·024	·013
Mean computed by Bessel's formula	29·731	29·668	29·568	29·438	29·311	29·219	29·204	29·265	29·392	29·543	29·673	29·736	...
Difference, observed—computed ...	−·004	·011	−·012	−·005	+·019	−·018	·006	·012	−·022	+·014	−·002	·000	...

The formula for the mean pressure of the n^{th} month after the middle of January is—

$$P_n = 29{\cdot}479'' + {\cdot}27094'' \sin (n\ 30^\circ + 101^\circ\ 32')$$
$$+ {\cdot}01419 \quad \sin (n\ 60^\circ + 235^\circ\ 17')$$
$$+ {\cdot}00222 \quad \sin (n\ 90^\circ + 228^\circ\ 41')$$

The pressures, thus computed, give the smoothly flowing curve in fig. 14, Plate XXV; but the residues in the last line of Table XII indicate that, if the higher terms of the formula were computed out, their co-efficients would be considerable, notwithstanding that the co-efficient of the third periodic term is little more than two thousandths of an inch. The computed mean pressure for July is ·015 inch less than that for June, though the observed pressure is somewhat greater.

According to the preceding formula, the barometer stands highest on the 28th of December, and lowest on the 11th of July. The first term alone would make these epochs fall on the 4th of January and 4th of July. The former of these dates coincides closely with the time of lowest temperature, and the latter is about the time when the density of the air is least, owing to the high temperature and the large proportion of water vapour it contains. The first term, therefore, represents the greater part of the change of pressure directly caused by the annual variations of temperature and absolute humidity. The second represents a smaller periodic variation, the minima of which (occurring about the 2nd of February and 2nd of August) coincide with the maxima of the winter and summer rains of Northern India. The first two periodic terms of the annual variation of pressure at Allahabad are almost exactly the same as those of Benares, given at page 152.

The normal pressure for each day of the year has been computed from the observations of five years, in the manner described above, under temperature. Table XIII contains the results :—

TABLE XIII.

Normal Daily Pressure at Allahabad.

Date.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	"	"	"	"	"	"	"	"	"	"	"	"
1st	29·733	29·709	29·594	29 489	29·362	29·252	29·180	29·203	29 336	29·467	29·600	29·707
2nd	·741	·712	·594	·505	·357	·242	·182	·214	·333	·470	·596	·707
3rd	·746	·713	·599	·513	·350	·236	·179	·220	·330	·479	·596	·710
4th	·749	·713	·603	·508	·340	·233	·176	·221	·330	·490	·602	·716
5th	·750	·709	·606	·494	·328	·232	·181	·220	·333	·492	·611	·725
6th	·751	·700	·606	·474	·319	·235	·197	·221	·335	·492	·622	·736
7th	·747	·691	·603	·451	·317	·237	·218	·226	·331	·494	·635	·742
8th	·742	·687	·598	·429	·320	·234	·232	·232	·319	·497	·650	·743
9th	·738	·687	·690	·413	·322	·222	·237	·242	·309	·505	·664	·743
10th	·738	·689	·578	·414	·322	·207	·237	·245	·310	·517	·674	·743
11th	·739	·695	·566	·401	·325	·199	·233	·214	·323	·531	·684	·742
12th	·741	·704	·560	·411	·336	·196	·228	·216	·340	·542	·694	·740
13th	·744	·704	·556	·431	·349	·193	·223	·253	·358	·550	·698	·740
14th	·745	·692	·550	·450	·359	·188	·220	·257	·372	·555	·692	·745

Normal Daily Pressure at Allahabad—continued.

Date.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	"	"	"	"	"	"	"	"	"	"	"	"
15th	29·739	29·678	29·549	29·459	29·363	29·183	29·216	29·256	29·380	29·562	29·683	29·752
16th	·730	·672	·551	·457	·363	·186	·211	·253	·381	·571	·679	·755
17th	·723	·677	·563	·451	·363	·194	·208	·256	·377	·582	·684	·757
18th	·722	·685	·574	·446	·361	·199	·209	·262	·371	·590	·690	·758
19th	·723	·689	·579	·443	·359	·197	·214	·283	·367	·595	·694	·758
20th	·724	·680	·579	·434	·358	·192	·220	·302	·362	·597	·698	·758
21st	·725	·662	·574	·416	·353	·188	·225	·318	·359	·600	·700	·758
22nd	·723	·644	·564	·399	·340	·184	·227	·328	·365	·604	·699	·757
23rd	·718	·641	·552	·393	·321	·182	·226	·331	·382	·607	·694	·757
24th	·713	·648	·537	·396	·302	·180	·225	·330	·404	·610	·690	·750
25th	·706	·650	·524	·400	·293	·179	·224	·333	·423	·611	·692	·737
26th	·703	·638	·515	·398	·294	·177	·219	·340	·436	·611	·698	·723
27th	·695	·619	·506	·392	·298	·174	·212	·353	·446	·610	·709	·712
28th	·693	·603	·494	·383	·299	·171	·203	·356	·454	·611	·710	·709
29th	·691	...	·481	·375	·291	·172	·195	·350	·459	·612	·711	·712
30th	·696	...	·472	·367	·279	·175	·190	·343	·460	·610	·709	·719
31st	·704	...	·475	...	·265	...	·193	·339	...	·605	..	·726
Mean	29·727	29·678	29·558	29·433	29·329	29·201	29·211	29·277	29·370	29·557	29·672	29·737
Mean of 1st 10 days	29·744	29 701	29·597	29·468	29·334	29 233	29·202	29·224	29·326	29·490	29·625	29·727
" 2nd 10 "	·733	·688	·563	·438	·354	·193	·218	·261	·363	·568	·690	·751
remaining days	·706	·638	·518	·392	·303	·178	·213	·338	·419	·608	·700	·733

The pressure is greatest on the 19th and 20th of December, and least on the 28th of June. From the 9th of October to the 29th of March, the pressure is above the annual average, and below it all the rest of the year; except during the first five days of April. For two months in the cold weather, between the 26th of November and the 26th of January, the normal daily pressure does not vary more than ·06 inch. There is a similar period of nearly uniform pressure near the annual minimum, between the 9th of June and 9th of August, when the daily mean pressure does not vary more than ·07 inch.

In the table, numerous minor fluctuations of pressure are discernible, the minima of which are nearly always followed immediately by cloudy weather and rain. The most important of these are retained in the ten-day means at the foot of the table; they may, perhaps, be better seen when represented graphically, as in fig. 14, Plate XXV.

The most remarkable deviations from the uniform flow of the pressure curve given by Bessel's formula are—

(1.) A depression in the beginning and a rise in the middle of May: the latter amounting to ·046 inch. This does not appear in Mr. Eliot's curves for other stations

in the North-Western Provinces in the years preceding 1875, but it is distinctly marked in Mr. C. Chambers' curves for Bombay, and is doubtless a regularly recurring phenomenon over a great part of Western and Central India.

(2.) A break in the rise of pressure between the mindle of July and the middle of August; the depression amounting to ·047 at the end of July. This is seen in Mr. Eliot's curves; and a similar depression is observed at Bombay, but it occurs there ten days earlier.

(3.) A similar interruption to the rise of pressure in September, well marked at other stations in the North-Western Provinces, and but faintly at Bombay. On the other hand, a depression in the beginning of February, noticed by Mr. Eliot, does not appear in the Allahabad curve, or is but faintly discernible.

Variability of Pressure.—In the third line, from the foot of Table XII, the probable errors of the monthly mean pressures computed from five-years' observations are given. Considering that this short period includes the years 1875 and 1877, (the years of highest and lowest pressure observed at Roorkee since 1864,) the probable errors of the averages are small, not amounting to a millimetre in any month. The probable error of the annual mean is only ·013 inch, or ·33 millimetre. August is the month of most uniform pressure, and in April the height of the barometer is most variable.

The extent of the variations of pressure during the five years may be more readily understood from the following table:—

Highest pressure at 10 A.M.	...	...	29·978″ on the 18th January 1877.
Lowest „ 4 P.M.	...	...	28·939″ „ 16th July 1875.
Highest daily mean ...	...	...	29·912″ „ 18th January 1877.
Lowest „ „ ...	...	...	29·008″ „ 16th July 1875.
Highest monthly mean	...	...	29·795″ in January 1877.
Lowest „ „ ...	...	...	29·153″ „ July 1876.
Greatest range in a month	...	...	0·547″ „ September 1875.
Highest annual mean	...	...	29·511″ „ 1877.
Lowest „ „	...	...	29·465″ „ 1875.
Greatest range in a year	...	...	1·010″ „ 1875.
„ „ in 5 years	...	...	1·039″

HYGROMETRY.

Since November 1874, both the absolute humidity, measured by the elastic force of vapour, and the relative humidity, or percentage of saturation of the air, have been recorded at all the hours of observation; the humidities being calculated from the individual observations of the dry and wet bulb thermometers. Up to the end of 1875, Apjohn's formula was used for the hygrometric calculations; but since 1876, it has been superseded by August's formula with Regnault's constants. The humidities computed by Apjohn's formula are somewhat higher than the truth, especially in the dry hot days of April and May, while August's gives results that agree better with the indications of a condensing hygrometer.[1] The following figures, taken from the registers of 1879,

[1] See Blanford, Journal of the Asiatic Society of Bengal, Vol. XLV, page 53.

compare the results of the two formulæ under the extreme conditions of heat and drought, heat and moisture, and cold and moisture :—

Date.	Hour.	Observed temperature.		Deduced by August's Formula.			Deduced by Apjohn's Formula.		
		Dry bulb.	Wet bulb.	Dew point.	Vapour tension.	Relative humidity.	Dew point.	Vapour tension.	Relative humidity.
1879.									
May 4th	4 P.M.	111·6°	70·6°	31·2°	·198″	7	41·6°	·296″	11
July 8th	4 P.M.	81·5°	80·7°	80·3°	1·037″	97	80·4°	1·040″	97
December 27th	4 A.M.	41·4°	39·2°	36·0°	·212″	81	36·4°	·216″	82

The humidities deduced by means of Apjohn's formula are always a little greater than those given by August's; but the difference is almost inappreciable, unless the degree of humidity is less than 25 per cent.

Vapour Tension.

Diurnal variation.—The diurnal variation of the elastic force of vapour in the air has been calculated in a manner similar to that employed for temperature and pressure. The controlling observations of 4, 10, 16 and 22 hours are those of the five years from November 1874 to October 1879. The hourly means of sixteen series of observations in each month contain many minor inequalities, that would probably disappear if the period of observation were extended; and therefore they were smoothed by Bloxam's method, before the five-year means at 6-hourly intervals were inserted. Table XIV contains the mean hourly pressures of vapour, thus corrected to represent five-year means :—

TABLE XIV.

Diurnal variation of the Mean Elastic Force of Vapour at Allahabad.

(Means of 16 sets of Hourly Observations in each month, corrected to 5-year means).

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Midnight	·342	·365	·400	·446	·585	·767	·928	·916	·892	·662	·428	·352	·593
1	·338	·361	·394	·439	·581	·761	·924	·912	·892	·654	·422	·318	·588
2	·334	·356	·392	·436	·580	·762	·923	·938	·891	·650	·415	·340	·585
3	·329	·352	·391	·437	·581	·772	·924	·931	·885	·619	·414	·335	·583
4	·325	·347	·394	·416	·588	·780	·925	·927	·881	·618	·413	·330	·581
5	·319	·347	·399	·448	·599	·781	·920	·925	·879	·618	·408	·326	·583
6	·313	·345	·406	·452	·617	·784	·919	·927	·881	·655	·406	·326	·581
7	·314	·351	·421	·469	·626	·784	·931	·933	·892	·672	·416	·331	·595
8	·326	·362	·431	·477	·621	·778	·943	·941	·906	·683	·432	·346	·604
9	·340	·369	·429	·464	·609	·774	·955	·949	·914	·678	·439	·358	·607

Diurnal variation of the Mean Elastic Force of Vapour at Allahabad—continued.

Hour.	Jan.	Feb.	March.	April	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.	Year
10	·355	·375	·425	·437	·590	·772	·958	·954	·923	·672	·410	·368	606
11	·369	·376	·413	·414	·572	·768	·955	·954	924	·664	·442	·375	·602
Noon	·369	·376	·402	·398	·557	·756	·955	·957	·914	·652	·444	·375	·596
13	·365	·374	·395	·381	·541	·738	·960	·963	·901	·634	·446	·372	·589
14	·366	·368	·393	·374	·527	·729	·964	·952	·899	·618	411	·367	·583
15	·368	·365	·395	·375	·513	·724	·959	·942	·896	·625	·440	·370	·581
16	·372	·371	·404	·381	·515	·716	·951	·945	·895	·654	·463	·387	·588
17	·381	·387	·420	·399	·527	·724	·944	·947	·910	·676	495	·402	·600
18	·384	·401	·433	·425	·534	·736	·949	·942	·922	·671	·484	·398	·607
19	·377	·399	·429	·445	·542	·779	·953	·939	·924	·660	·468	·384	·608
20	·369	·382	·421	·447	·552	·783	·949	·939	·921	·656	·455	·373	·604
21	·360	·377	·414	·446	·562	·778	·950	·943	·915	·657	·443	·366	·601
22	·352	·371	·409	·446	·575	·772	·955	·948	·904	·662	·433	·361	·599
23	·346	·367	·406	·451	·584	·770	935	·948	·894	·664	·430	·356	588
Means	·351	·368	409	·431	·570	·762	·943	·943	·902	·657	·438	·360	·594

In the cold weather months, the pressure of vapour is least about 6 A.M., that is, at the coldest time of the day. There is another minimum about the time when the temperature is highest, between 1 and 3 P.M. The forenoon maximum occurs shortly before twelve o'clock, and that of the evening about 6 P.M. During the hot and dry months—March, April, May, and June—the absolute minimum occurs between 2 and 4 P.M.; and, in the morning hours, the quantity of vapour in the air is least between 2 and 3 A.M. (In June this minimum falls between 1 and 2 A.M.). In the rainiest months of the year, July and August, the diurnal variation of vapour tension is almost directly proportional to that of temperature, the minimum occurring between 5 and 6 A.M., and the maximum about 1 or 2 P.M. The mid-day depression is still, however, faintly marked, and about 10 P.M. there is, apparently, a slight increase of vapour pressure, the cause of which is not very obvious. In September, the variation is similar to that which obtains in August, except that there is no increase at 10 P.M.; and probably, further observations will show that this evening maximum is not a normal feature of the diurnal variation of vapour tension, in July and August. The great variations in form of the vapour tension curves, from month to month, are shown in Plate XXVI, figs. 1 to 12.

On the average of the whole year, the elastic force of vapour varies, during the diurnal period, in a manner very similar to that of the barometric pressure; three of the turning points of the two phenomena being almost exactly the same. The evening maximum of vapour tension occurs, however, about 7 P.M., while that of atmospheric

pressure is attained more than three hours later, between 10 and 11 P.M. The near coincidence of the other epochs must be more or less accidental, for it appears only in the annual averages. Moreover, the morning minimum of vapour tension is equal to that of the afternoon, on the average of the year, while the barometric pressure is much lower in the afternoon than in the morning. The diurnal variations of vapour tension and atmospheric pressure are connected with each other, in so far as they are both effects of the diurnal inequality of temperature, but it is doubtful whether there is any other connection between them, except in an indirect way. At a dry station like Allahabad, where the range of the inequality of vapour tension is less than one-fourth of the range of pressure, it could never be supposed that the observed variation of the barometer is *caused* by the variation of the quantity of aqueous vapour in the air.

The afternoon minimum of vapour in the atmospheric strata near the ground, most distinctly marked in the months when no dew is deposited at night, and when little or no evaporation goes on during the day, is probably caused by the upward diffusion of vapour. In an atmosphere where the degree of humidity is far below the saturation point, the vapour tension will be directly proportional to the absolute temperature, so long as no diffusion takes place; but the rate of diffusion will be proportional to the square of the absolute temperature. In such an atmosphere, the pressure of vapour will go on increasing up to a certain point, as the temperature rises; and will then diminish, when diffusion more than counterbalances the increase of elastic force due to increase of temperature or to evaporation. Cloud observations indicate that such vertical diffusion does actually take place.[1]

The evening maximum is caused, according to Kreil's theory of the barometric tides, by the contraction and sinking of the upper layers of the atmosphere, the consequent dynamic heating of the cloud-bearing strata, and the dispersion of the clouds they contain, followed by a downward diffusion of some of the vapour thus formed. According to this theory, the evening maximum of vapour tension would probably occur later than 6 or 7 P.M., the average hour given by the observations. It is unsafe, however, to theorize, or to test a theory, with only 16 days' observations for each month to go upon.

Annual variation.—Table XV gives the mean monthly values of the tension of vapour at Allahabad, for the five years 1875—79. These are the means of four observations, taken daily at equal intervals of six hours. Like the 6-hourly means of pressure

---

[1] Mr. Blanford has pointed out to me that the afternoon minimum of vapour tension near the ground, and the nearly simultaneous maximum of cloud, may be caused by the semi-diurnal interchange between the lower and upper currents of the atmosphere suggested by Dr. Köppen in the *Zeitschrift für Meteorologie*, B. XIV, p. 333. The transference of vapour from the lower to the cloud-bearing strata of the air might certainly be effected by such an interchange of the winds, if it really exists, even more readily than by simple diffusion.

Another cause that probably accounts for part of the afternoon minimum in the hot weather months, is the prevalence of hot winds at that time of the day, blowing from the drier regions to the west and north-west of Allahabad; though, owing to the dryness of the ground about the station, the increase of vapour in the evening when the wind has ceased to blow can only be very slight.

these are exactly equal, on the average of the whole year, to the means of twenty-four hourly observations, and the maximum difference in any month is ·003 inch :—

TABLE XV.

Mean Monthly and Annual Vapour Tension.

(Means of 4 observations).

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept	Oct.	Nov	Dec.	Year.
1875	·325	·402	·481	·464	·604	·886	·984	·964	·930	·623	·413	·376	·621
1876	·312	·295	·356	·330	·521	·741	·698	·873	·832	·678	·447	·343	·553
1877	·428	·349	·450	·531	·592	·784	·862	·891	·831	·612	·474	·424	·605
1878	·364	·431	·392	·486	·630	·640	1·006	1·002	·982	·618	·454	·318	·613
1879	·325	·354	·356	·325	·491	·746	·986	·980	·928	·704	·365	·306	·573
Mean	·351	·366	·407	·428	·567	·760	947	·944	·901	·659	·431	·353	·593
Probable error	·032	·035	·038	·064	·039	·062	·043	·039	·045	·022	·029	·032	·019
Mean computed by Bessel's formula	·350	·398	·404	·439	·566	·752	·926	·959	·864	·657	·449	·352	...
Difference, observed — computed ...	+ ·001	− ·032	+ ·003	− ·011	+ ·001	+ ·008	+ ·021	− ·015	+ ·037	+ ·002	− ·018	+ ·001	...

The monthly means indicate that, about the beginning of the year, when the temperature of the air is lowest, the pressure of vapour is lowest; and that, in the first four months, the quantity of vapour increases very slowly as the temperature rises. Before the setting in of the rains, and for sometime after their commencement, the proportion of aqueous vapour increases rapidly, and attains its maximum about the end of July. The annual variation of the elastic force of vapour may be represented approximately by the formula—

$$F_n = 0{\cdot}593'' + {\cdot}3124'' \sin (n\,30^\circ + 250^\circ\,15') + {\cdot}0858'' \sin (n\,60^\circ + 31^\circ\,34') + {\cdot}0120'' \sin (n\,90^\circ + 29^\circ\,33')$$

The last two lines of Table XV contain the monthly means calculated by this formula, and the differences between the observed and computed values. These differences are greatest in February and September. According to the formula, the minimum pressure of vapour occurs about the 2nd of January, and the maximum on the 6th of August. The former of these dates is a little before the time of lowest temperature, and the latter about a week after the heaviest rainfall of the year.

In Table XVI the normal daily values of the tension of vapour, computed in the same way as those of temperature and pressure, are given :—

TABLE XVI.

Normal Daily Elastic Force of Vapour at Allahabad.

Date.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1st	·333	·335	·340	·423	·464	·674	·931	·950	·949	·839	·497	·376
2nd	·337	·329	·340	·421	·480	·677	·916	·962	·959	·835	·471	·375
3rd	·343	·331	·344	·421	·489	·678	·957	·970	·963	·826	·453	·382
4th	·344	·337	·350	·422	·493	·678	·964	·972	·959	·810	·450	·389
5th	·340	·345	·357	·416	·497	·684	·962	·972	·952	·792	·463	·390
6th	336	·353	·366	·406	·513	·694	·952	·968	·946	·776	·484	·387
7th	·337	·359	·371	·399	·530	·696	·939	·962	·946	·762	·498	·383
8th	·343	·364	·377	·398	·513	·682	·929	·958	·948	·744	·491	·381
9th	·354	·368	·387	·401	·553	·659	·926	·955	·948	·721	·468	·377
10th	·370	·371	·404	·414	·556	·641	·934	·952	·943	·703	·444	·366
11th	·388	.366	·425	·440	·549	·640	·947	·944	·933	·697	·433	·349
12th	·399	·355	·445	·471	·539	·650	·955	·933	·916	·697	·428	·334
13th	·398	·348	·459	·486	·537	·661	·953	·924	·904	·697	·424	·329
14th	·389	·353	·463	·472	·546	·671	·946	·921	·894	·694	·420	·330
15th	·382	·362	·460	·440	·553	·686	·940	·918	·886	·689	·417	·335
16th	·378	·365	·453	·413	·559	·707	·935	·915	·882	·681	·417	·340
17th	·375	·365	·442	·402	·568	·739	·941	·914	·883	·673	·418	·344
18th	·367	·369	·423	·405	·582	·775	·948	·920	·889	·660	·423	·344
19th	·359	·380	·403	·415	·592	·808	·951	·930	·890	·635	·426	·339
20th	·351	·398	·393	·424	·595	·832	·951	·941	·882	·600	·424	·330
21st	·341	·414	·393	·429	·592	·851	·948	·944	·872	·569	·414	·320
22nd	·331	·422	·398	·429	·588	·863	·945	·946	·870	·552	·399	·316
23rd	·323	·411	·403	·426	·586	·869	·946	·947	·876	·546	·389	·321
24th	·317	·391	·411	·424	·589	·877	·956	·948	·879	·544	·384	·336
25th	·314	·378	·423	·426	·599	·890	·968	·949	·871	·538	·396	·352
26th	·317	·372	·433	·430	·613	·903	·974	·947	·852	·531	·401	·365
27th	·327	·364	·438	·435	·632	·910	·969	·941	·835	·524	·400	·374
28th	·338	·350	·435	·441	·651	·912	·953	·933	·829	·522	·397	·372
29th	·346	...	·428	·446	·663	·913	·936	·929	·833	·526	·391	·363
30th	349	...	·425	·451	·668	·921	·929	·932	·838	·525	·383	·348
31st	·344	...	·425	...	·670	...	·925	·939	...	·516	...	·336
Mean	·351	·366	·407	·428	·567	·761	·947	·943	·901	·659	·430	·354
Mean of 1st 10 days	·344	·349	·364	·412	·512	·676	·944	·962	·951	·781	·480	·381
„ of 2nd 10 „	·379	·366	·437	438	·562	·717	·947	·926	·896	·672	·423	·337
„ of remaining days	·332	·388	·419	·434	·622	·891	·950	·941	·856	·536	·395	·346

According to this table, the vapour tension attains its maximum on the 4th or 5th of August, and reaches its lowest on the 22nd of January. There is another minimum, about the 22nd of December, nearly as low, and the date of minimum deduced from the above formula lies between the two; the increase of vapour pressure about the middle of January not being represented in the formula. The tensions in this table are subject to numerous fluctuations of small range and short period. Some of these would doubtless disappear, if the observations were extended over a longer time; but others are of a normal character and re-appear every year: for example, the maxima about the 12th of January and 14th of March.

At the middle of May, the vapour pressure first begins to increase rapidly; the rise, from the 15th to the 28th of that month, being nearly a tenth of an inch. It then rises slowly until the 12th of June, when it again increases suddenly, going up 2-10ths of an inch between the 12th and 21st. The most rapid decrease takes place in the first ten days of October; the difference between the mean vapour tensions of the 3rd and 9th exceeding a tenth of an inch. These peculiarities of the annual variation are shown in the broken curve of fig. 14, Plate XXVI.

Variability of vapour tension.—The tension of vapour is one of the most variable meteorological elements observed in this part of India. The probable errors of the monthly means, derived from five years' observations, are greater than those of the 5-year means of pressure; and in April and June these probable errors exceed 6-10ths of an inch. The quantity of vapour in the air is so variable in June, because the rains, which usually commence about the middle of that month, are sometimes early and sometimes late; the great variability of vapour tension in April is due to the high temperature of the month, combined with the fact that it is usually rainless; but sometimes has a few showers (as in 1877), the evaporation of which produces a great increase in the proportion of vapour in the air near the ground.

The maximum tension of vapour at any hour of observation was 1·208," at 10 A.M. on the 21st July 1878. The minimum was ·138," at 4 A.M. on the 5th February 1876. On the former of these dates, the daily mean was 1·120", and on the latter only ·175".

Relative Humidity.

Diurnal variation.—Table XVII exhibits the hourly values of the mean degree of humidity for each month, calculated from the same data and in the same way as the hourly vapour tensions given in Table XIV:—

TABLE XVII.

Mean hourly Humidity at Allahabad.

(Means of 16 sets of hourly observations in each month, corrected to 5-year means).

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Midnight	82·1	73 3	57·7	45·4	51·0	59·5	81·3	86 9	85·7	84·3	81·0	84 7	72 7
1	83 9	75·4	59 0	47·5	52 5	60 1	81·8	87·4	87·7	84·7	82·6	86·1	74·1
2	85·3	77·5	60 2	49·6	53·9	60 4	82·9	87·5	88·3	85·6	83 9	86 7	75·2
3	86·2	79 2	61·9	51·4	55·5	63·1	84·5	87·8	88·6	87·1	85 2	87·2	76·5

Mean hourly Humidity at Allahabad—continued.

Hour.			Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
4	...	...	86·8	81·0	64·4	53·6	57·6	64·6	85·8	88·2	89·2	88·2	86·8	89·2	77·8
5	...	...	87·0	82·4	66·4	55·6	60·0	64·6	85·7	88·6	90·1	89·0	86·6	88·7	78·7
6	...	...	86·6	82·6	66·8	55·2	60·0	64·1	84·3	88·3	89·9	89·5	85·3	88·7	78·4
7	...	...	84·9	79·8	63·6	50·4	55·5	61·5	81·6	86·6	87·8	86·3	81·3	86·7	75·5
8	...	...	79·8	71·6	54·6	42·5	48·0	56·3	78·2	83·5	83·7	78·4	72·6	80·1	69·1
9	...	...	70·9	61·2	44·4	34·8	41·8	49·4	74·8	79·5	78·6	68·6	61·6	69·5	61·3
10	...	...	62·2	53·2	37·0	29·0	35·0	46·4	71·6	75·6	74·6	60·6	52·0	59·2	54·7
11	...	...	56·6	47·2	32·0	24·4	30·8	43·1	69·1	73·1	71·3	54·6	45·3	51·7	49·9
Noon	...	...	51·3	42·9	28·8	21·7	28·0	40·7	69·0	72·2	68·0	50·5	41·9	46·3	46·8
13	...	...	47·6	40·1	26·7	19·7	26·1	38·9	68·5	71·7	66·1	47·9	38·7	43·0	44·6
14	...	...	46·5	38·5	26·0	19·0	24·8	38·3	67·7	70·5	65·7	46·4	38·1	41·6	43·6
15	...	...	46·6	37·8	26·2	19·3	24·7	38·4	67·7	70·4	66·4	47·5	39·1	42·6	43·9
16	...	...	49·6	39·3	27·8	20·4	25·6	39·0	67·8	72·0	68·4	53·2	45·4	49·0	46·4
17	...	...	57·2	45·8	32·1	21·2	27·8	41·4	69·2	73·6	72·8	61·9	56·6	59·9	51·6
18	...	...	66·1	54·8	37·9	26·8	31·2	46·1	73·8	77·3	78·1	68·2	65·3	68·3	57·8
19	...	...	71·6	61·5	43·3	32·5	35·0	50·7	76·6	80·6	81·7	72·0	69·2	73·4	62·3
20	...	...	74·5	64·9	46·8	36·2	38·7	53·6	78·9	82·7	83·7	75·3	71·6	76·4	65·3
21	...	...	76·4	66·9	49·3	38·8	42·0	55·4	80·6	84·5	84·7	78·4	74·0	78·5	67·4
22	...	...	78·0	69·0	52·2	41·0	45·6	57·0	81·4	85·0	85·2	80·8	76·4	81·0	69·4
23	...	...	80·0	71·1	55·7	43·5	48·8	58·5	81·4	86·0	85·7	83·1	79·0	83·0	71·3
Means	...	...	70·7	62·4	46·7	36·6	41·7	52·1	76·8	80·8	80·1	71·8	66·7	70·9	63·1

The diurnal inequality of absolute humidity is so small, that the relative humidity or hygrometric state of the air is determined almost entirely by the temperature. The percentage of saturation, therefore, varies inversely with the temperature, as Table XVIII indicates; and the maximum of the one coincides as nearly as possible with the minimum of the other, and *vice versâ.* The diurnal range of humidity is usually very great, amounting to 35 per cent. on the average of the year, and to 50 per cent. in November; but in August it is little more than 18 per cent.

The first thirteen figures of Plate XXVII represent the hourly variation of humidity for each month and for the whole year.

Annual variation.—Observations of relative humidity taken at 10 A.M. and 4 P.M., fairly comparable with each other, exist for the whole ten years; and for the whole period, except the months mentioned above under the section on temperature, observations at 10 P.M. and 4 A.M. have also been recorded. The means of four observations for the months in which four daily observations were taken, have been accepted as approximate diurnal means, though they are about 1 per cent. too low, because the mean of four equidistant observations of temperature is a little too high. For those months in which the night observations are wanting, the mean humidity at 10 A.M. and 4 P.M. has been converted into

an assumed diurnal mean by multiplying with a factor computed from the observations of the same month in other years. This method of calculating daily means is hardly legitimate, for there is no evidence that both the range and the general character of the diurnal variation were the same in those months as in other years, but the error introduced by this process does not seem very great. Table XVIII gives the monthly means for ten years. It will be seen that the averages at the foot are considerably greater than those for the last five years in the rainy season, June to September, and less in the winter months. Three of the last five years, 1876, 1877, and 1878, had much less than the average rainfall in the summer months, and were unusually cold and moist in winter. In 1877, this abnormal character of the season was most marked, and the most humid month of that year was not August, but January:—

TABLE XVIII.

Mean relative humidity (per cent.) for each month of 10 years. Means of four Observations).

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1870	61·0	56·3	56·0	50·7	33·1	58·1	81·4	82·8	79·9	74·3	66·3	62·7	63·5
1871	62·2	58·9	42·0	43·8	42·6	77·4	88·0	86·1	86·6	63·0	57·2	67·8	64·6
1872	80·5	62·9	46·2	48·2	44·5	60·7	79·2	86·1	83·5	65·2	63·3	69·2	66·0
1873	64·5	60·8	47·5	37·5	41·7	45·3	83·5	83·2	80·8	64·7	64·0	71·0	62·0
1874	65·0	55·0	41·2	32·8	33·0	70·2	83·3	87·2	80·8	69·7	68·5	68·8	63·0
1875	66·5	66·7	48·0	36·3	45·7	64·0	83·8	88·0	84·7	69·5	64·5	70·0	65·6
1876	60·7	48·0	41·0	27·0	36·8	47·0	75·2	75·5	75·5	80·5	71·3	73·2	59·3
1877	82·2	71·7	57·0	50·2	44·0	54·0	63·0	64·8	64·2	64·3	59·0	72·5	62·2
1878	74·0	62·8	41·5	41·2	49·3	38·2	75·0	83·8	85·7	62·3	62·5	62·2	61·5
1879	62·3	54·0	39·2	25·3	29·0	55·5	86·2	89·0	86·5	77·0	62·0	67·3	61·1
Mean	67·9	59·7	46·0	39·3	40·0	67·0	79·9	82·6	80·8	69·4	63·9	68·5	62·9
Probable error	5·4	4·6	4·3	6·2	4·6	8·0	4·9	5·0	4·6	4·2	2·8	2·6	1·5
Mean computed by Bessel's formula	69·2	61·1	47·5	37·8	40·4	56·6	75·8	84·2	78·5	68·8	65·8	68·6	...
Difference, observed — computed ...	—1·3	—1·4	—1·5	+1·5	—0·4	—0·4	+3·9	—1·6	+2·3	+0·6	—1·9	—0·1	...

The hygrometric state of the air, being an inverse function of the temperature as well as a direct function of the absolute humidity, has two maxima in the twelve months; one in August, about the time when the quantity of vapour in the air is greatest, and the other in January, when the temperature is lowest. The annual variation of the relative humidity of the air may be represented by the formula—

$$
\begin{aligned}
H_n = 62{\cdot}9 &+ 16{\cdot}55 \sin (n30^\circ + 190^\circ\ 50') \\
&+ 11{\cdot}19 \sin (n60^\circ + 59^\circ\ 11') \\
&+ 0{\cdot}47 \sin (n90^\circ + 194^\circ\ 21')
\end{aligned}
$$

The angles are counted from the middle of January, as in the previous formulæ for the annual variations. This formula represents the mean humidity of any month very closely, except in April, and in July, August, and September. In these latter months the observed mean humidity is nearly constant, while that calculated by the formula is higher in August than in July or September. In fig. 14, Plate XXVII, the observed and calculated figures have been plotted together. The annual maxima occur about the beginning of January and the 22nd of August, and the minima about the 24th of April and the middle of November.

It has not been thought worth while to work out the normal humidity of each day separately.

Variability of relative humidity.—The hygrometric state of the air is very variable in every month. It is most variable in June and least so in December. The average degree of humidity for the whole year is, however, remarkably constant; the probable error of the ten-year mean being only 1·5 per cent. This is due to the circumstance that a warm and dry "cold weather" is almost invariably followed by a cool and rainy summer, while the summer rains are scanty when the previous winter has been cold and moist.

The lowest degree of humidity recorded at any hour of observation was 6 per cent. at 1 P.M. on the 28th April 1879. In the months of April and May, the degree of humidity frequently falls as low as 10 per cent. during the afternoons, and in the cold weather and rainy season it, of course, sometimes reaches complete saturation.

CLOUD.

The proportion of cloudy sky, estimated in tenths of the whole expanse, has been entered in the register for each hour of observation, during the last five years; and for the day hours (10 A.M. and 4 P.M.) in the earlier years. Cloud observations being taken by personal estimation only, and not by reading any instrument, may be expected to vary a good deal with different observers; but the estimates made by the several observers who have been employed at Allahabad appear to agree very well.

Diurnal variation.—The data for computing the hourly variation of cloud for each month are for the same period of observation as those employed in the discussion of vapour tension and humidity, and they have been combined in exactly the same way:—

TABLE XIX.

Diurnal variation of Cloud at Allahabad (in tenths).

(Means of 16 sets of hourly observations in each month corrected to 5-year means.)

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Midnight	1·42	2·16	1·89	1·25	1·56	2·93	5·91	6·16	4·71	1·30	0·58	1·19	2·58
1	1·60	2·51	2·16	1·16	1·49	3·00	5·85	6·29	4·24	1·34	0·62	1·28	2·63
2	1·71	2·51	2·14	1·01	1·54	3·19	6·28	6·19	4·10	1·40	0·58	1·48	2·68
3	1·93	2·48	1·71	1·05	1·60	3·79	6·62	6·06	4·24	1·50	0·58	1·41	2·75
4	2·10	1·70	1·39	1·41	2·04	4·37	6·69	6·37	4·67	1·61	0·57	1·25	2·85

Diurnal variation of Cloud at Allahabad (in tenths)—continued.

Hour.			Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
5	...	...	2·30	1·61	1·43	1·94	2·59	4·80	6·63	6·87	5·59	1·67	0·57	1·24	3·11
6	...	...	2·35	2·00	1·99	2·07	2·56	4·87	6·57	7·06	6·45	2·04	0·65	1·58	3·35
7	...	...	2·33	2·67	2·55	1·95	2·04	4·76	6·30	7·09	6·60	2·21	0·69	1·81	3·42
8	...	...	2·30	2·71	2·46	1·77	1·68	4·48	6·59	6·97	6·30	2·15	0·70	1·88	3·53
9	...	...	2·29	2·32	1·84	1·58	1·66	4·18	7·34	6·86	5·80	2·03	0·78	1·76	3·20
10	...	...	2·49	2·17	1·68	1·42	1·58	4·12	7·66	7·01	5·43	1·94	0·83	1·61	3·16
11	...	...	2·65	1·92	2·21	1·18	1·41	4·31	7·94	7·19	5·80	1·68	0·72	1·50	3·23
Noon	...	...	2·64	1·82	2·69	0·94	1·47	4·31	8·09	7·45	6·18	2·16	0·65	1·49	3·32
13	...	...	2·71	1·85	2·67	0·87	2·04	4·47	8·00	7·68	6·20	2·32	0·63	1·71	3·43
14	...	...	2·94	2·13	2·47	1·20	2·68	4·99	7·90	7·71	5·93	2·20	0·77	1·93	3·57
15	...	...	2·97	2·42	2·43	1·66	2·52	5·33	7·94	7·39	5·67	2·03	1·04	1·80	3·60
16	...	..	2·71	2·59	2·50	2·02	2·11	5·41	7·95	7·19	5·69	2·00	1·16	1·64	3·59
17	...	...	2·49	2·58	2·82	2·61	2·03	5·38	7·69	7·42	5·66	2·21	1·23	1·33	3·62
18	...	...	2·40	2·35	2·43	2·70	2·11	5·32	7·92	7·51	5·14	1·81	1·22	1·04	3·50
19	...	...	2·25	1·92	1·67	2·11	1·86	4·87	7·76	7·40	4·25	1·31	0·91	0·96	3·11
20	...	...	1·91	1·66	1·28	1·33	1·31	4·11	6·87	7·19	4·09	1·38	0·60	0·92	2·73
21	...	...	1·78	1·67	1·47	0·98	1·25	3·48	6·49	6·59	4·30	1·40	0·50	0·84	2·57
22	...	...	1·62	1·56	1·64	1·07	1·61	2·99	6·62	6·18	4·47	1·26	0·45	0·78	2·52
23	...	...	1·40	1·65	1·77	1·19	1·74	2·81	6·46	6·10	4·65	1·30	0·48	1·05	2·55
Means	...	..	2·22	2·12	2·05	1·52	1·85	4·26	7·05	6·91	5·26	1·77	0·73	1·39	3·10

The proportion of cloud for each month is greater in the day than in the night hours. This relation has been observed by Kreil at Vienna and by Neumayer at Melbourne. The cause is, doubtless, either the upward diffusion of water vapour when the sun is above the horizon, or the possible ascent of the lower and descent of the upper atmospheric currents in the day time. In the rainy season, and in January, the maximum of cloud occurs at the hottest time of the day, when the humidity of the air near the ground is least; but, in the dry months, it generally occurs later, about 4 or 5 P.M. In every month, there is a secondary maximum in the morning, usually about 6 or 7 A.M.; that is, at the time when the temperature of the air is lowest. The smallest proportion of cloud is observed between 8 P.M. and midnight, or about 10 P.M. on the average of the year. There is another minimum occurring between 9 A.M. and noon, or at 10 A.M. on the average of all the months. In some months also, there is an apparent increase of cloud about the hour of sunset, but this may be a mere optical effect, due to the lighting up of thin films of cirrus that were previously invisible. The cloud variations represented in the first thirteen curves of Plate XXVIII are not very regular, but there is in all of them an obvious tendency to a double oscillation in the daily period.

The humidity of the air in the cloud-bearing strata is greatest, on the average, when the temperature is lowest, and when the vapour contained in the air reaches a maximum by diffusion from below. It is least at the times of highest barometric pressure, when, according to Kreil's theory, the cloud-bearing strata are dynamically heated by the sinking and compression of the overlying air. This seems to be the most reasonable explanation of the evening minimum. That of the morning is probably caused simply by the dissipation of cloud by the sun's heat before diffusion begins to increase the humidity of the upper strata. Few as are the observations on which Table XIX is founded, they confirm in a very striking manner the deductions from Kreil's theory given by Mr. Blanford in explanation of the diurnal variation of rain frequency at Calcutta,[1] and this close agreement of theory and observation speak well for the care with which the observer, Babu Káder Náth Chatterjee, has made his cloud estimations since he commenced work in 1876.

Annual variation.—The annual inequality of cloud is very similar to that of the relative humidity of the lower atmosphere. Since the beginning of 1870, cloud observations at 10 A.M. and 4 P.M. have been made nearly every day, and the monthly means of these have been adopted for determining the annual variation, though Table XIX shows that they are always a little too high:—

TABLE XX.

Mean Cloud Proportion for each month of ten years.

(Means of 2 observations).

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1870	1·80	3·26	3·74	1·79	1·08	5·25	7·36	7·00	4·84	2·65	0·71	1·89	3·45
1871	2·66	2·43	1·34	1·71	1·94	6·48	8·73	8·49	8·21	0·23	1·95	4·15	4·03
1872	4·65	2·38	2·95	3·30	0·42	5·10	8·85	9·13	8·28	2·10	1·27	2·29	4·23
1873	2·66	1·98	1·05	0·93	3·36	4·00	9·13	7·27	5·33	0·13	0·98	1·21	3·17
1874	2·76	2·02	2·84	0·73	1·20	8·13	9·13	9·66	6·73	2·24	1·27	2 18	4·07
1875	1·95	3·65	0·17	0·35	1·45	5·55	7·70	7·45	5·90	0·95	0·35	1·45	3·08
1876	0:62	0·70	2·85	0·85	0·85	3·80	8·35	7·05	6·15	2·00	0·90	1·20	2·94
1877	6·15	2·45	4·30	3·60	3·20	6·00	7·10	5·25	3·10	2·85	1·20	3·80	4·08
1878	3·70	2·50	1·10	3·40	1·95	2·90	7·50	7·75	6·84	1·58	1·83	0·61	3·47
1879	0·59	2·61	2·03	0·40	1·78	5·53	8·39	8·01	5·83	2·47	0·70	1·05	3·28
Mean	2·75	2·40	2·24	1·71	1·72	5·27	8·22	7·71	6·12	1·72	1·12	1·98	3·58
Probable error	1·25	0·49	0·88	0·86	0·55	1·00	0·51	0·83	1·04	0·66	0·34	0·80	0·32

[1] Jour. As, Soc., Bengal, Vol. XLVIII, Part II, p. 45.

The cloudiest times of the year are the middle of January and the latter half of July: the least cloudy are the end of April and the second week of November. The annual variation is represented in fig. 14, Plate XXVIII.

Variability of cloud.—The probable errors at the foot of Table XX indicate that the extent of cloudy sky is most variable in January and at the beginning and end of the rains. In January, the probable error is nearly half the ten years' average, that month being sometimes almost cloudless, as in 1876 and 1879, and sometimes nearly as cloudy as the rainy season, for example, in 1877. In the year with least cloud, 1876, there was no winter rain, and the summer rains were very light; while, in 1874, when the cloud proportion for the whole year was greatest, both winter and summer rains were heavier than usual.

Rain.

The data available for determining the mean rainfall of Allahabad are the following:—

(1.) The registers kept at the Meteorological Observatory for the years 1870—1879 and parts of 1868 and 1869.

(2.) A record kept at the Tahsildar's Office, about a quarter of a mile from Dr. Irving's house, where the observatory used to be situated, and three quarters of a mile from the present position of the observatory, at the residence of the Meteorological Reporter. This goes back to June 1860.

(3.) Monthly totals of rainfall recorded at the Collector's Office in the years from June 1844 to October 1855, published by the Board of Revenue.

The rain-gauge used at the observatory hitherto, has been one of Symons' construction. The collecting funnel is 5 inches in diameter, and it has always been placed about a foot above the ground. The instrument has been tested and found to read correctly to within a very small fraction of the total rainfall.[1]

The rain-gauge at the Tahsil is one of Fleming's pattern, with a funnel mouth, 6 inches in diameter, leading to a vertical cylindrical tube 3 inches wide, in which moves a float carrying a graduated rod. A gauge of this construction generally reads too low, and the defect is increased in this case, by the instrument being placed on the roof of a house, about 20 feet above the ground.

Diurnal variation.—The hourly observations of four days in each month for four years are not sufficiently numerous to determine the diurnal inequality of rain frequency with any approach to exactness. Out of 192 observations at each hour, rain was observed to be falling the following number of times:—

Hour.	No of rain observations	Hour.	No of rain observations
Midnight	... 8	5	... 12
1	... 11	6	... 8
2	... 9	7	... 10
3	... 11	8	... 5
4	... 10	9	... 6

[1] At 60° F. the mean diameter of the funnel was found to be almost exactly 5 inches The quantity of distilled water at this temperature, which filled the measuring glass up to the 1 inch mark, weighed 321·7 grammes. A cylinder of pure water, 5 inches in diameter and 1 inch high, should weigh 321 42 grammes at this temperature.

Hour.	No. of rain observations.	Hour.	No. of rain observations.
10	8	17	2
11	7	18	7
Noon	11	19	6
13	7	20	8
14	6	21	5
15	4	22	6
16	6	23	6

These numbers indicate, more or less distinctly, the existence of a double oscillation in the 24 hours, similar to that of the proportion of cloudy sky, but not exactly coinciding with it. It is probable, therefore, that further observations will modify these figures very considerably, and render them much more like those representing the diurnal variation of rain frequency at Calcutta, which is very similar to that of cloud at Allahabad. A rain-gauge, attached to Osler's anemometer, was in use at Lucknow from April 1868 to March 1877 (with interruptions amounting to several months); and its traces, when tabulated, show that, at Lucknow, rain is most frequent about the coldest and hottest times of the day, and falls least frequently at 10 A.M. and 10-30 P.M. The morning maximum appears to be the greater at Lucknow, while at Calcutta rain falls oftenest in the afternoon.

Annual variation.—It is now generally known that, in Upper India, especially in the Panjáb, there are two rainy seasons in each year, the greater extending over the three and half months of the "south-west monsoon" in summer, and the less occurring in the cold-weather months of January, February, and March. In the eastern half of the North-Western Provinces, the winter rains are quite insignificant in quantity, but some rain falls in the cold season almost every year.

During the ten years 1870—79, rain, amounting to at least a hundreth of an inch, was measured on 657 days. These were distributed among the months as follows:—

January	21 rainy days.	August	182 rainy days.
February	13 ,, ,,	September	122 ,, ,,
March	13 ,, ,,	October	28 ,, ,,
April	15 ,, ,,	November	2 ,, ,,
May	16 ,, ,,	December	3 ,, ,,
June	75 ,, ,,		
July	167 ,, ,,	TOTAL	657 ,, ,,

Rain is thus most frequent in August, when the humidity of the air attains its maximum, and least frequent in November. There is a secondary maximum in January and another minimum in March. The year of most frequent rainfall was 1879, when rain was measured on 80 days, whereas, in 1873, the number of rainy days was only 50.

The mean rainfall of the ten years was—

January	0·76 inches.	August	11·25 inches.
February	0·32 ,,	September	7·52 ,,
March	0·36 ,,	October	2·37 ,,
April	0·33 ,,	November	0·02 ,,
May	0·36 ,,	December	0·21 ,,
June	4·78 ,,		
July	13·76 ,,	TOTAL	42·04 ,,

In the next table, the normal rainfall of each day, calculated from ten-year averages, by Galle's process, described above, is given :—

TABLE XXI.

Normal Daily Rainfall at Allahabad.

(Calculated from 10-year means).

DATE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	"	"	"	"	"	"	"	"	"	"	"	"
1st	·01	·01	...	...	·02	·06	·41	·98	·23	·03	·01	...
2nd	·01	·01	...	...	·01	·06	·31	·79	·21	·01	...	...
3rd	·01	·01	...	...	·01	·05	·28	·66	·22	·01	...	...
4th	·01	·02	...	...	·01	·05	·33	·57	·29	·01	...	...
5th	...	·03	...	...	...	·04	·39	·43	·37	·03	...	...
6th	...	·05	·01	·01	...	·03	40	·31	·38	·09	...	...
7th	...	·06	·01	·01	...	·02	·39	·28	·29	·19	·01	..
8th	...	·05	·01	·01	·01	·03	·36	·34	·22	·30	·01	...
9th	·01	·03	...	·01	·01	·07	·32	·42	·21	·31	...	·01
10th	·02	·01	...	...	·02	·12	·28	·45	·24	·21	...	·01
11th	·05	·01	...	·01	·03	·13	·24	·43	·27	·10	...	·01
12th	·08	·01	·01	·01	·03	·10	·22	·37	·27	·03	...	...
13th	·09	·01	·01	·02	·02	·08	·25	·30	·28	·01	...	...
14th	·07	·01	·02	·02	·01	·11	·36	·27	·31	·01	...	...
15th	·04	·01	·04	·02	·01	·16	·53	·29	·32	·01	...	...
16th	·02	·02	·06	·01	·01	·17	·60	·30	·25	·01	...	...
17th	·01	·02	·05	·01	·01	·13	·49	·30	·20	·01	...	...
18th	·01	·01	·04	...	.02	·12	·32	·31	·18	...	...	...
19th	·01	...	·02	·01	·02	·15	·24	·31	·19	...	...	...
20th	·01	...	·01	·01	·02	·21	·26	·34	·23	...	...	...
21st	·01	...	...	·02	·01	·24	·29	·38	·29	·01	...	·01
22nd	·01	...	...	·03	·01	·24	·30	·39	·34	·05	...	·03
23rd	·03	...	...	·02	·01	·21	·31	·34	·33	·12	...	·05
24th	·04	...	...	·01	·01	·19	·33	·27	·28	·19	...	·03
25th	·05	...	...	...	...	·18	·37	·22	·25	·20	...	·01
26th	·04	...	...	...	...	·20	·40	·22	·27	·14	...	...
27th	·03	...	...	·01	...	·26	·47	·25	·26	·08	...	...
28th	·02	...	...	·01	...	·36	·67	·25	·21	·06	...	...
29th	·01	...	...	·02	·01	·49	·96	·24	·15	·07	...	·01
30th	·01	...	...	·02	·02	·47	1·20	·24	·08	·07	...	01
31st	·01	...	·01	...	·04	...	1·18	·25	...	·04	...	01
TOTAL ...	0 72	0 38	0·30	0 30	0 38	4 73	13·46	11·50	7·61	2·40	·03	·19

The heaviest rain falls on the 30th and 31st of July. There are several maxima for the winter rains, the chief of which occur on the 13th of January and the 2nd of February. Other distinct maxima of rain occur in the hot season, on the 16th March, the 14th April, and the 1st June; each being followed by a decided lowering of the temperature, as described above. In the rainy season also, as has already been pointed out, every increase in the normal rainfall, like that which occurs at the end of July, is followed by a decrease of the normal temperature, and a rise of temperature accompanies every "break" or diminution of the normal rainfall.

The heaviest fall of rain, recorded in one day, during the ten years, was 15·48 inches, from 10 A.M. on the 29th to 10 A.M. on the 30th July 1875. Other falls exceeding 4 inches were the following:—

7·85	inches	on the	16th July 1871.
7·25	"	"	4th August 1872.
6·26	"	"	31st July 1873.
5·81	"	"	11th September 1879.
5·26	"	"	9th October 1876.
4·75	"	"	28th July 1872.
4·61	"	"	9th August 1872.

There is an obvious tendency for heavy downpours to occur about the end of July and beginning of August, the enormous rainfall of the 29th and 30th July 1875 being no exceptional phenomenon, but merely an exaggerated instance of a frequently recurring one. In his Report on the Meteorology of India for 1875, Mr. Blanford has pointed out that the heavy rainfall of the country round Allahabad at the end of July that year was accompanied by a storm of a cyclonic character which had proceeded inland from the coast of Orissa. The daily telegraphic weather reports, that have been published in more recent years, show that such minor cyclones or eddies are by no means infrequent in the height of the rainy season, and that they generally move along the line separating the westerly winds of Southern India from the easterly winds of the northern plain,—a line which here nearly coincides with the Ganges river. The barometric depression noticed at the beginning of August, and the frequency of south-west winds at Allahabad and Benares about that time, are such as would accompany these storms.

The rainy season may be supposed to commence, in a normal year, either on the 15th of June, when the normal daily rainfall first exceeds ·15 inch, or on the 20th, when the rainfall exceeds ·20 inch. The end of the season, in ordinary years, is about the 30th September, when the normal rainfall falls below ·10 inch; but there are sometimes heavy showers in October, which render the normal value of the rainfall for that month, founded on a ten years' averages, very uncertain.

Average rainfall.—A period of ten years being too short to determine the average rainfall of a place very exactly, the registers (2) and (3), mentioned above, have been used to extend that of the observatory. Together, the three registers cover a period varying from 30 to 32 years in the different months. The register for the eleven and a

half years, from May 1844 to October 1855, gives an annual average of 41·09 inches. This differs less than an inch from the average of the last ten years at the observatory. For the decade 1860—69, excepting some months of 1868 and 1869, the tahsil record is the only one available; and since the gauge was 20 feet above the ground, and probably would have indicated too little rain even on the ground, the figures require to be corrected before they can be compared with others.

The average rainfall of the last ten years, at the tahsil, was 37·61 inches, against 42·04 inches at the observatory. The tahsil gauge therefore registers, on the average, only 89 per cent. of the total rainfall, and the proportion is less in the dry than in the rainy months, as the following table shows :—

Month.	Percentage.
January	84
February	78
March	67
April	52
May	80
June	100
July	91
August	89
September	84
October	93
November	0
December	90

The ratio between the rainfall of the rainiest months—June to October—at the observatory, and that recorded at the tahsil, is 1·10; and the ratio for the dry months, taken all together, is 1·33. For the years 1860 to 1867, and for January, February, and September 1868, and June, July, and October 1869, the monthly totals of the tahsil gauge have been taken and increased by 1-10th in the rainy season and 1-3rd in the dry season, to get the most probable amounts of rainfall. Taking these figures, and the observatory totals for the other months of 1868 and 1869, the average rainfall of Allahabad for the years 1860—69 comes out 40·54 inches. The averages for the three periods 1844—55, 1860—69, and 1870—79, thus differ little more than an inch, and the average of all three series, 41·18 inches, may be accepted as the most probable value of the mean annual rainfall of Allahabad. This accords very well with the average rainfalls of places near the Ganges and Jumna, east and west of Allahabad, as given in my report on the rainfall of the North-Western Provinces and Oudh, published in 1879. For example, the average rainfall of Mirzapur for the fifteen years, 1864—78, was 42·76 inches, that of Handia, 41·19 inches, that of Karchana, 40·33 inches, and that of Mau, on the Jumna, west of Allahabad, 40·33 inches.

The monthly and annual totals for the individual years are given in Table XXII. The break between 1855 and 1860 was caused by the mutiny. The rainfall of 1855-56 should have appeared in the Revenue report for that year, but, owing to the mutiny and the disturbed tate of the country that followed it, no report was published, and the rainfall register appears to have been lost. It was not until 1860, that regular observations of rainfall were re-commenced.

TABLE XXII.

Monthly and Annual Rainfall at Allahabad.

Year.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Authority.
		"	"	"	"	"	"	"	"	"	"	"	"	"	
1844	...	?	?	?	?	·10	...	14·25	16·57	5·07	...	...	·30	?	N. W. P. Rainfall Statements up to April 1850.
1845	...	·37	2·70	·72	1·42	·77	4·99	7·83	15 81	2·92	...	...	·65	38·18	
1846	...	...	·42	·25	...	...	6·82	8·66	6·27	10·77	...	...	...	33·19	Ditto.
1847	...	1·29	...	...	...	...	3·35	15·30	14·13	8·05	6·65	1·50	...	50·27	Ditto.
1848	...	...	...	...	...	·45	3·60	11·15	5·05	1·60	1·90	·30	...	24·05	Ditto.
1849	...	2·53	...	..	...	...	4·06	1·00	15·02	3·00	3·82	...	...	29·43	Ditto.
1850	...	2·20	2·14	...	...	...	4·94	11·12	12·75	8·60	3·75	...	...	45·50	Revenue Reports.
1851	...	4·20	1·05	·70	...	...	3·05	18·40	13·90	9·70	3·42	...	...	55 32	Ditto.
1852	...	·30	...	3·47	...	·11	9·68	18·69	6·79	3·60	·77	...	·54	43·95	Ditto.
1853	...	2·36	·58	...	·35	...	2·17	14·50	5·55	·75	1·95	...	...	28·21	Ditto.
1854	...	...	20	...	...	·12	17·91	7·84	17·14	6·86	4·65	5·26	...	60 98	Ditto.
1855	...	·29	·25	3·15	1·40	...	3·26	19·32	1·48	14·76	...	...	...	?	Ditto.
1856	...													?	......
1857	...													?	......
1858	...													?	......
1859	...													?	......
1860	...	?	?	?	?	?	·83	12·21	7·81	12·98	3·30	...	...	?	Tahsil Records (corrected).
1861	...	·13	...	...	...	...	5·72	10·34	4·51	16·83	4·18	...	...	41·71	Ditto.
1862	...	·13	...	1·73	...	2·60	·44	22·00	25·63	4·40	1·32	...	...	57·65	Ditto.
1863	...	...	...	...	...	·13	6·93	10·12	11·99	4·84	5·17	...	...	39·18	Ditto.
1864	...	...	·67	...	...	...	·22	2·86	9·90	3·74	...	...	...	17·39	Ditto.
1865	...	2·13	1·20	2·00	...	3·33	1·65	25·85	6·38	2·20	...	...	·80	45·54	Ditto.
1866	...	·13	·13	...	·27	...	1·65	10·34	10·12	6·71	...	...	...	29·35	Ditto.
1867	...	1·60	1·87	...	...	2·00	3·96	15·07	9·13	20·57	2·42	...	...	56·62	Ditto.
1868	..	·80	·27	·18	·17	·03	4·18	6·12	·79	14·96	...	...	...	27·50	Observatory Registers.
1869	...	...	...	·40	...	...	2·20	10·45	7·15	18·30	12·43	...	·45	51·38	Ditto.
1870	...	...	...	·93	·79	...	4·47	16·50	16·86	10·69	10·28	...	...	60·52	Ditto.
1871	...	·11	·33	...	1·10	·74	15·48	24·79	7·36	11·81	...	...	1·51	63·23	Ditto.
1872	...	2·10	·22	...	...	·33	2·97	11·54	25·92	5·36	...	...	...	48·44	Ditto.
1873	...	·14	·54	·52	...	...	·03	16·48	7·22	7·90	...	...	...	32·83	Ditto.
1874	...	...	...	·56	...	...	6·67	15·58	8·93	8·50	·22	...	...	40·46	Ditto.
1875	...	·49	·43	...	...	1·07	3·49	26·33	12·63	7·74	·10	...	...	52·28	Ditto.
1876	...	...	...	...	...	...	1·29	10·05	10·75	4·50	6·23	...	...	32·82	Ditto.
1877	...	2·01	1·56	1·36	·44	·08	3·59	2·23	5·67	·39	3·38	...	·60	21·31	Ditto.
1878	...	2·72	·03	·25	·99	1·39	·57	8·07	7·59	4·36	...	·24	...	26·21	Ditto.
1879	...	...	·07	·02	...	...	9·26	6·01	9·58	13·95	3·46	...	...	42·35	Ditto.
Mean	...	·87	·52	·54	·23	·41	4·37	12·84	10·51	8·01	2·48	·24	·16	41·18	
Years	...	(30)	(30)	(30)	(30)	(31)	(32)	(32)	(32)	(32)	(32)	(31)	(31)	(30-32)	

In the averages at the foot of the table, the figures for November are probably too high. In twenty-seven years out of thirty-one, that month was rainless, and if the exceptionally heavy fall of November 1854 be left out, the mean for the month is reduced to ·07 inch. The heavy rain of November 1854 was common to all the south-eastern districts of the North-Western Provinces, and was probably due to the advance inland of one of the cyclonic disturbances that frequently occur in the Bay of Bengal about the beginning of that month.

Variations of long period.—The annual totals in the previous table indicate, though obscurely, that there may be an inequality of rainfall with a period of ten or eleven years, similar to the variation in the sun-spot cycle detected by Mr. Meldrum and other observers. It is to be regretted that the break in the registers between 1855 and 1860 prevents any very satisfactory testing of the truth of this indication.

In a previous paper,[1] it has been pointed out that the winter and summer rains of Northern India vary inversely; and before inquiring whether the supposed variation is observable in the rainfall of Allahabad or not, it is necessary to tabulate the winter and summer rains separately. This has been done in the next table. The "winter rain" of each year in this table, means the rainfall from the previous November to April inclusive, and the "summer rain" that of the months from May to October :—

TABLE XXIII.

Winter and Summer Rainfall Totals.

Year.	Winter.	Summer.	Year.	Winter.	Summer.	Year.	Winter.	Summer
	"	"		"	"		"	"
1844	?	36 01	1856	?	?	1868	1·42	26 08
1845	5 51	32·32	1857	?	?	1869	·40	50 53
1846	1 32	32 52	1858	?	?	1870	2·17	58 80
1847	1·29	47·48	1859	?	?	1871	1·54	60 18
1848	1·50	23 75	1860	?	36 63	1872	3 83	46 12
1849	2 83	26 90	1861	·13	41·58	1873	1·20	31 63
1850	4 34	41·16	1862	1 86	55 69	1874	·56	39·90
1851	5 95	49 37	1863	...	39 18	1875	·92	51·36
1852	3 77	39 64	1864	·67	16 72	1876	...	32 82
1853	3 83	24 92	1865	5·33	39·41	1877	5 37	15 04
1854	1·20	59 78	1866	1·33	28 82	1878	4·59	21·98
1855	10 35	38 82	1867	3·47	53·15	1879	·33	42 26

[1] Variation of rainfall in Northern India, *ante* pages 184 and 209.

[2] May wanting.

When these figures are arranged in 11-year series, the first terms of which corre-

spond to the years 1838, 1849, 1860, and 1871, and then averaged, the means being smoothed by Bloxam's method, we get the following results :—

	Year.	Winter rain.	Summer rain.
		"	"
(Sun-spot maximum)	11th	1·67	43·25
	1st	2·24	41·70
	2nd	2·68	43·18
	3rd	2·55	43·43
	4th	1·92	38·93
	5th	1·81	36·39
	6th	2·96	37·14
(Sun-spot minimum)	7th	4·52	34·79
	8th	3·93	33·73
	9th	1·85	38·02
	10th	1·13	43·25
(Sun-spot maximum)	11th	1·67	43·25

These figures are by no means regular; but the summer rain, on the whole, appears to vary directly with the sun-spots, and the winter rain inversely.

The winter rainfall appears to have been much less since than before 1860. The mean for the eleven years, 1845—55, was 3·81 inches, or, if the unusually heavy rain of November 1854 be neglected, 3·33 inches. That of the nine years, from 1861 to 1869, was only 1·62 inch, and that of the last ten years 2·00 inches. The summer averages for these periods show a small but progressive increase. It is therefore possible that the seasons in North India are undergoing a very slow secular or periodic change.

WIND.

The least satisfactory of the observations hitherto taken at Allahabad are those relating to wind. This is much to be regretted; because, next to those of barometric pressure, no observations afford a greater insight into the relations between various meteorological phenomena than those of wind, when properly made.

At Allahabad, the direction of the wind has been taken at the hours of observation, from a vane mounted on a post, about 15 feet high. This post, is placed in the most open part of the "compound," but trees much higher than it rise at a distance of about forty yards on the west. On the other sides it is better exposed. On the whole, the mean directions computed from the Allahabad observations by Lambert's formula agree, however, fairly well with those of Benares, where the exposure of the wind vane is all that can be desired.

For some years, a small anemometer, constructed on Robinson's principle, has been used to determine the velocity of the wind. At the present site of the observatory there is no place where it could be mounted, and it has therefore been put up on the roof of the building now occupied by the Muir College, at a height of 30 feet above the ground. The exposure of this instrument is also not so good as one could wish, and the velocities given by it are probably too low. Owing to the distance of the anemometer from the other instruments (nearly a mile) it has only been read once or twice a day.

Diurnal variation.—In no part of the world is the diurnal variation of the velocity of the wind more distinctly marked than in North India, especially during the hot season.

Strong hot winds, sweeping clouds of dust before them, blow down the valley of the Ganges in the day time, but they gradually die away about sunset, and the nights are almost always calm. For the reason above stated, no hourly observations of wind velocity have been taken at Allahabad, and therefore this variation of the strength of the wind cannot be illustrated by tables.

The direction of the wind was noted at each hour of the sixteen days, in each month on which hourly observations of the other meteorological elements were taken. Observations at 4 A.M., and 10 P.M., as well as at the same hours in the day time, were also taken nearly every day, in the four years, 1876—79. These served to correct, in some degree, the results derived from the hourly observations of a few days. Since sixteen observations at each hour are too few to yield a reliable mean for so variable an element as wind, the months have been combined into groups of four each, corresponding as nearly as possible to the three Indian seasons—the cold, the hot, and the rainy. The mean hourly rectangular components of the wind direction have then been computed by Lambert's formula and corrected, as described above, by the insertion of the results of four years' daily observations at the hours 4, 10, 16, and 22, the figures for all the other hours being slightly changed in proportion. Finally, from these corrected rectangular components the resultant direction and percentage have been computed in the usual way:—

TABLE XXIV.

Hourly Components and Resultants of the Wind at Allahabad.

(In percentages of number of Observatories)

Hour	November to February				March to June				July to October				Whole Year			
	Components		Resultants		Components		Resultants		Components		Resultants		Components		Resultants	
	North	East	Per cent	Direction	North	East	Per cent	Direction	North	East	Per cent	Direction	North	East	Per cent	Direction
Midnight	11.99	− 8.21	14.53	N 34° W	10.19	−13.79	17.32	N 53° W	4.57	− 1.03	4.68	N 13° W	9.02	− 7.68	11.84	N 40° W
1	10.06	− 9.81	14.05	N 44° W	11.44	−11.61	18.55	N 52° W	5.71	− 3.23	6.56	N 29° W	9.07	− 9.22	12.93	N 45° W
2	9.74	−11.74	15.25	N 50° W	13.98	−12.50	19.02	N 43° W	7.61	− 2.84	8.12	N 20° W	10.44	− 9.16	13.88	N 41° W
3	11.35	−14.74	18.36	N 52° W	14.30	−10.48	17.72	N 36° W	7.35	0.33	7.33	N 3° E	11.01	− 8.30	13.78	N 37° W
4	11.70	−17.11	20.77	N 55° W	5.90	− 8.92	10.69	N 57° W	5.99	2.35	6.43	N 21° E	7.89	− 7.89	11.15	N 45° W
5	14.49	−17.21	22.49	N 50° W	−2.57	−13.51	13.78	S 79° W	1.51	1.53	2.14	N 45° E	4.39	− 9.73	10.67	N 66° W
6	14.48	−16.17	21.70	N 48° W	−6.06	−19.85	20.75	S 73° W	0.94	− 1.70	1.93	N 62° W	3.11	−12.57	12.94	N 76° W
7	12.36	−17.15	21.14	N 54° W	−5.90	−22.23	22.99	S 75° W	5.42	− 2.41	5.93	N 24° W	3.89	−13.93	14.48	N 74° W
8	10.26	−22.1	24.28	N 65° W	−3.15	−20.39	20.67	S 81° W	6.13	− 2.57	6.65	N 23° W	4.31	−14.99	15.60	N 74° W
9	5.82	−25.34	25.99	N 77° W	1.09	−19.97	19.99	N 87° W	5.66	− 3.99	6.93	N 35° W	4.19	−16.43	16.95	N 75° W
10	4.50	−20.37	20.86	N 77° W	8.52	−21.16	22.81	N 68° W	5.41	− 7.61	9.35	N 54° W	6.15	−16.39	17.49	N 69° W
11	12.10	−15.69	19.76	N 52° W	17.11	−22.33	28.13	N 53° W	8.39	−10.69	13.59	N 52° W	12.[illegible]3	−16.22	20.19	N 52° W
Noon	21.77	−17.35	27.83	N 39° W	26.24	−23.62	33.82	N 47° W	15.10	− 8.21	17.18	N 29° W	21.04	−18.09	27.74	N 41° W
13	25.06	−20.51	32.33	N 39° W	36.86	−33.95	50.11	N 43° W	23.27	− 3.50	23.53	N 9° W	28.40	−19.21	34.31	N 34° W
14	29.00	−22.[illegible]2	36.59	N 38° W	42.38	−34.29	54.51	N 39° W	23.67	0.14	23.67	N 1° E	31.[illegible]8	−18.82	36.84	N 31° W
15	33.62	−21.91	40.17	N 33° W	41.26	−31.55	51.94	N 37° W	21.75	2.43	21.68	N 6° E	32.21	−17.04	36.43	N 28° W
16	32.82	−20.90	38.90	N 33° W	43.56	−29.98	52.31	N 34° W	19.97	2.41	20.10	N 7° E	32.12	−15.82	35.80	N 26° W
17	24.68	−16.09	29.96	N 35° W	43.65	−23.71	49.84	N 28° W	16.23	4.17	16.60	N 14° E	28.27	−12.18	30.77	N 23° W
18	17.73	−11.60	21.18	N 33° W	35.57	−17.65	39.70	N 27° W	15.65	10.21	18.69	N 33° E	22.08	− 6.35	23.84	N 15° W
19	16.71	− 8.65	18.84	N 2[illegible]° W	21.59	−12.77	27.69	N 27° W	12.10	12.93	17.77	N 47° E	17.84	− 2.43	18.04	N 8° W
20	16.[illegible]	− 7.99	18.27	N 26° W	16.90	− 5.49	19.67	N 16° W	6.13	10.67	12.35	N 60° E	13.53	− 0.94	13.92	N 4° W
21	14.54	− 7.[illegible]	16.[illegible]2	N 25° W	13.43	− 1.29	13.52	N 5° W	3.30	7.52	8.21	N 66° E	10.43	− 0.54	10.44	N 3° W
22	13.01	− 7.30	[illegible]	N 29° W	8.56	− 4.30	9.62	N 27° W	3.69	4.77	6.03	N 52° E	8.92	− 2.31	8.63	N 16° W
23	12.32	− 7.18	14.25	N 30° W	8.10	−10.06	12.91	N 51° W	5.52	1.49	5.71	N 15° E	8.65	− 5.25	10.13	N 31° W
Means	16.[illegible]1	−15.26	21.99	N 43° W	17.01	−18.04	24.79	N 47° W	9.64	+ .55	9.66	N 3° E	14.24	−10.02	17.05	N 35° W

The resultant percentages for the night hours are small at all seasons, owing to the large proportion of calms. The steadiness and velocity of the wind, in every season, are greatest about the hottest hour of the day. In this respect, the winds of Allahabad conform to the general rule for stations near sea-level, in every part of the world, as given by Dr. Hann in his paper on the daily period in the velocity and direction of the wind, read before the Vienna Academy in January 1879.

The mean direction of the wind is subject to distinct diurnal and semi-diurnal variations. These are somewhat irregular in the cold weather, but similar in general character in the hot and rainy seasons, and the semi-diurnal variation is best marked in the rains. The resultant wind directions are most northerly in the afternoons and most southerly in the mornings, between 9 and 10 A.M. in the cold weather, and at 6 or 7 A.M. in the hot weather and rainy season. The variation of the north component is very similar to that of the barometric pressure inverted, especially in the dry season. This may be observed on comparing fig. 5, Plate XXIX, with the curves above it. At all seasons, the resultant wind is most easterly (or least westerly) at 8 or 9 P.M., and most westerly between 9 and 11 A.M. The east and west component has apparently no direct relation to the barometric pressure, but attains its greatest westerly value at the hottest time of the day, when the barometer is falling rapidly. The diurnal rotation of the wind is direct, or with the sun in this part of India, at all seasons, and not retrograde in the rainy season, as was inferred from the observations taken at Benares at 10 A.M. and 4 P.M.[1]

In the diagrams on Plate XXX, the double diurnal rotation of the wind about its mean direction is graphically represented. The range of variation from east to west is greatest in the rainy season, but the curves for the hot and rainy seasons are similar. The curves approximate to ovals, with one axis parallel to the mean direction of the wind; but the lines joining the points for certain of the night hours form a re-entrant loop, indicating that between 10 or 11 P.M. and 3 or 4 A.M. the variation of the wind is similar to that which obtains during the day, though its strength and persistency are much less. The loop representing the nocturnal rotation is greatest in the rainy season and least in the dry. It has thus probably some relation to the quantity of vapour in the air and the form of the barometric tidal wave, as has been pointed out by Mr. F. Chambers.[2] With Mr. Chambers's paper on the winds of Bermuda diagrams are given, showing that the nocturnal variation of the wind at that station is nearly equal to the variation during the day, just as the nocturnal barometric tide is nearly equal to the diurnal one. At Allahabad, especially in the hot season, the range of the barometer at night is very small compared to its range during the day, and the nocturnal variation of the wind is also inconsiderable. But in the rainy season, when the climate in the interior of India has more of a maritime character, both the nocturnal range of the barometer and the amplitude of the variation of the wind during the night increase.

At continental as well as at marine stations, it appears, therefore, that one would be justified in inferring that there is a very intimate connection between the diurnal

[1] See Rainfall of Benares in relation to the prevailing winds, page 148 *ante*.

[2] See Philosophical Transactions for 1873, page 1, and Proc. R. S for 1876, page 402

variation of the wind and the barometric tides; but it does not follow that Mr. Chambers's opinion as to which of the two phenomena is the cause and which the effect must be accepted. It is to be hoped that the traces of the anemographs that have recently been erected at several stations in the interior of India will serve to throw some further light on this interesting question. All that can safely be inferred from the observations taken at Allahabad is, that in the interior of continents the wind is subject to a diurnal variation almost as well marked as that of the land and sea breezes on the coast.

Annual variation.—Observations of the wind direction at 10 A.M. and 4 P.M. were taken throughout the ten years, 1870—79, with the exception of a few days noted at the foot of Table XXV. This table contains the mean components and resultants for each month, computed from the two daily observations, along with the total number of observations in each month, tabulated under eight points, and the daily velocity given by from five to six years' readings of an anemometer. The mean direction, calculated from the 10 A.M. and 4 P.M. components in the preceding table, differs only 2° from that calculated from all the observations:—

TABLE XXV.

Summary of the Wind Observations of the ten years, 1870—79.

(*Observations at 10 A.M. and 4 P.M.*)

Month	Number of Observations.									Mean Components (per cent).		Resultants		Mean velocity.
	North	North-east	East	South-east	South	South-west.	West.	North-west.	Calm.	North	East.	Per cent.	Direction	(Miles per diem)
January ..	82	44	107	14	20	35	183	79	56	+18·60	—18·64	26·3	N. 45° W.	43·4
February ..	57	20	78	19	28	32	232	62	36	+ 9·03	—34·20	35·4	N. 75° W.	60·1
March ...	54	28	54	20	29	46	241	117	28	+13·04	—43·76	45·7	N. 73° W.	59·8
April[1]	70	32	92	20	28	40	173	108	29	+16·65	—25·15	30·1	N. 56° W.	65·4
May .	70	66	104	40	30	28	166	106	10	+18·31	—13·19	22·6	N. 36° W.	80·1
June .	56	76	114	16	24	45	158	85	26	+17·12	—11·81	20·8	N. 35° W.	81·0
July[2] ...	54	56	164	23	35	66	110	37	41	+ 3·54	+ 1·14	3·7	N. 18° E.	91·0
August ...	40	84	113	25	26	67	152	40	43	+ 5·91	— 1·22	6·0	N. 12° W.	80·2
September ...	54	74	116	20	22	41	138	60	45	+13·77	+ 0·51	13·8	N. 2° E	62·0
October ..	62	56	81	33	32	31	197	51	77	+ 9·71	—17·91	20·4	N. 61° W	35·0
November[3] ...	61	24	47	9	26	60	209	63	81	+ 8·23	—38·89	39·8	N. 78° W	25·8
December .	62	37	66	11	31	49	211	73	77	+12·15	—31·82	34·1	N. 69° W	27·2
Year .	722	597	1,196	250	334	540	2,203	881	549	+12·17	—19·58	23·0	N. 58° W.	58·7

[1] The observations of four days in 1875 are wanting.

[2] The observations of one day in 1873 and one in 1876 are wanting.

[3] The observations of ten days in 1874 are wanting.

West winds are much more frequently observed than those from any other quarter, and next in order of frequency come east winds; those from north and south being seldom observed. In these respects, the winds of Allahabad resemble those of Benares. The mean direction for the whole year at Allahabad is, however, 14 degrees more northerly than at Benares. Part of this difference is perhaps due to the circumstance, mentioned above, that the wind vane is nearer to large trees on the west than on any other side; but, from the normal distribution of pressure over the eastern half of the North-West Provinces in the rainy season, there is reason to believe that the winds of Allahabad, at that time of the year, are really more northerly than those of Benares. The variations of the east and west components at the two stations agree very closely. There are two westerly maxima in March and November, and two easterly in July and September; while, at the middle of the rainy season, in August, westerly winds prevail. The meridional components for the two stations are not so much alike; but both have a northerly maximum in the cold weather and another in May, and both attain their least northerly or greatest southerly value in July and August. There is also, at both stations, a remarkable backing of the wind towards the south about the beginning of March.

The resultant direction of the wind, at Allahabad, for the three rainiest months, July, August, and September, deduced from ten years' observations, at 10 A.M. and 4 P.M., is from N. 1° E., with a frequency of only 8 per cent. This indicates that, in the rainy months, easterly and westerly winds nearly balance each other. For the nine dry months, the resultant direction, on the mean of ten years, is from N. 62° W., with a percentage of steadiness equal to 29·5. These directions are represented by the lines joining the points A and B with the point surrounded by a circle in fig. 5, Plate XXX. The variation of the wind, between the dry and rainy season at Allahabad, takes place along the line joining the points A and B, the bearing of which is N. 77° W. to S. 77° E., or very nearly west-north-west to east-south-east. This is the direction of a line passing through or near Allahabad, Chittagong, and Mooltan, and is parallel to the general axis of the Himalayan mountain chain and of the great plain of Northern India.

The direction of variation of the "monsoons" at Benares, when worked out in the same way from the data given in Part I, page 151, is N. 75° W. to S. 75° E.

The most important difference, in the annual variations of the winds of Benares and Allahabad, is the small negative value of the east component at Allahabad in January. This perhaps indicates that the easterly current which brings the winter rains blows more frequently at Allahabad than at Benares.

The velocity of the wind is least at the end of November, and greatest about the commencement of the rains in June.

Relations of wind to rainfall.—The quantity of rain collected in each month of the ten years, and the number of days on which it fell, have been tabulated under the principal wind-directions. The results embodied in Table XXVI confirm, in a general way, the conclusions already arrived at from a discussion of the Benares registers, regarding the relations between wind and rainfall, on the southern border of the Gangetic plain.

TABLE XXVI.

Rainfall of the ten years, 1870—79, at Allahabad, tabulated under eight points of the compass.

Month.	Rainy days.									Rainfall in inches.								
	North.	North-east.	East.	South-east.	South.	South-west.	West.	North-west.	Calm.	North.	North-east.	East.	South-east.	South.	South-west.	West.	North-west.	Calm.
January	2	4	13	1	...	...	1	...	...	0·09	2·24	4·40	0·53	..	...	0·22	...	..
February	...	3	6	2	...	...	1	1	1	...	1·35	1·33	0·09	...	...	0·01	0·22	0·18
March	1	4	...	...	1	4	1	2	...	0·07	0·83	...	...	0·40	1·72	0·10	0·43	...
April	...	1	5	2	1	3	...	1	2	...	0·16	2·11	...	0·04	0·40	...	..	0·61
May	2	2	4	...	1	4	1	...	2	0·74	0·26	1·47	..	0·06	0·02	0·00	0·29	0·08
June	3	12	20	8	5	6	13	4	4	1·20	4·59	13·04	4·60	4·00	6·08	9·76	1·92	2·14
July	15	15	38	11	10	19	39	9	12	7·21	11·60	19·24	6·96	12·05	28·28	39·87	7·36	5·00
August	11	29	39	9	9	21	35	12	17	6·14	18·62	25·54	2·31	4·74	13·64	20·29	6·18	6·05
September ...	9	23	37	12	1	7	15	7	11	2·34	13·77	35·17	4·09	0·46	4·18	7·10	2·90	4·30
October	3	4	12	1	...	2	2	2	2	5·30	0·79	15·01	0·02	...	0·57	0·10	0·29	1·59
November	...	1	...	...	...	...	...	...	1	...	0·10	...	...	...	...	...	...	0·14
December	...	1	2	...	...	...	...	...	...	...	0·41	1·70	...	...	...	...	...	...
Total ...	46	99	175	40	28	66	107	38	52	23·09	54·71	120·00	18·49	21·84	54·49	67·14	18·59	20·09
Total smoothed by Bessel's Formula	33	119	152	66	16	72	103	44	53	0·87	73·66	09·83	88·08	9·13	61·40	82·35	26·04	20·09

The numbers at the foot of the table have been computed by means of the first two periodic terms of the formula of sines. They serve to determine approximately the directions of greatest and least rainfall and rain frequency, *viz.*:—

	Maxima.	Minima.
Frequency...	N. 80°E.	S. 1° E.
	S. 83°W.	N. 17°W.
Rainfall ...	N. 84°E.	S. 6° E.
	S. 80°W.	N. 14°W.

These directions closely agree with the wettest and driest wind directions at Benares.

From the numbers at the foot of Tables XXV and XXVI, we can calculate the probability that rain will fall at some time during a day, when the wind between 10 A.M. and 4 P.M. blows from any given point. Expressed in the form of percentages, these probabilities are—

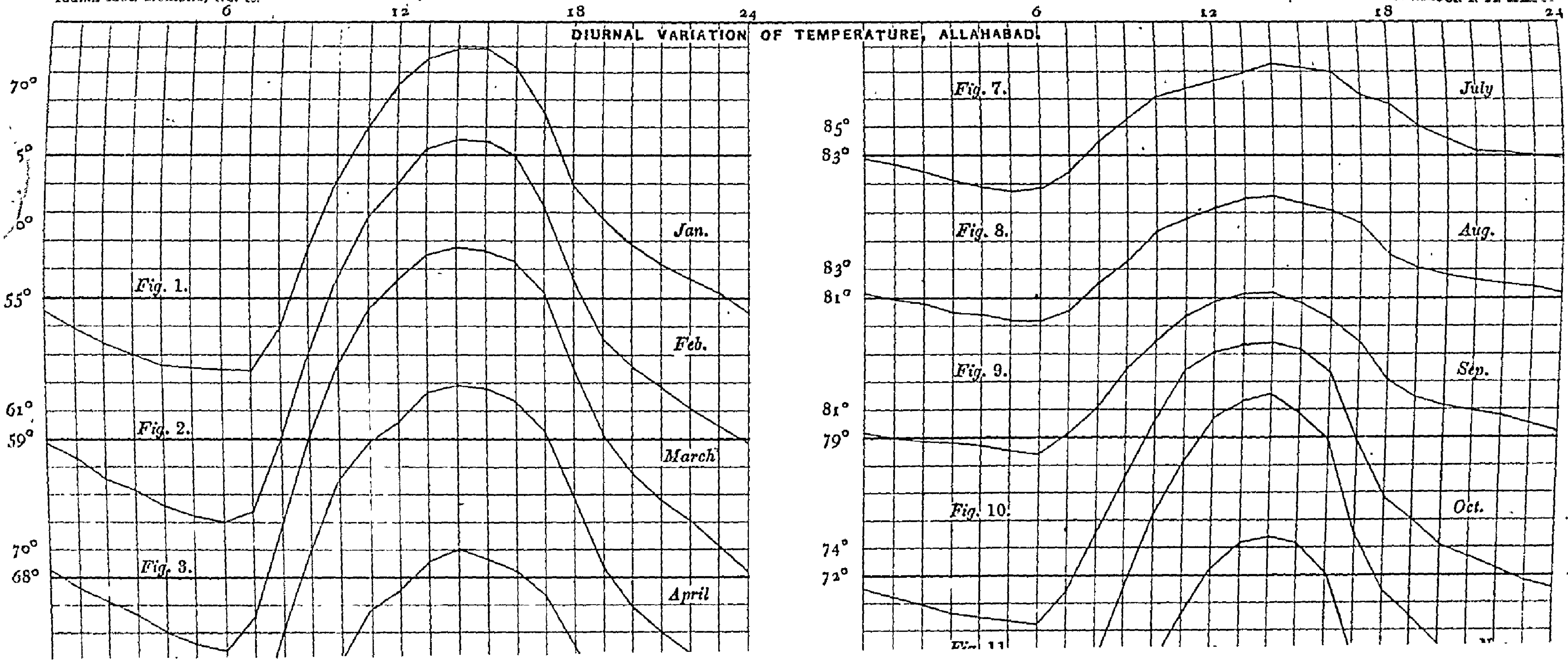
N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
12·7	33·2	29·3	36·8	16·7	24·4	9·7	8·6	19·9

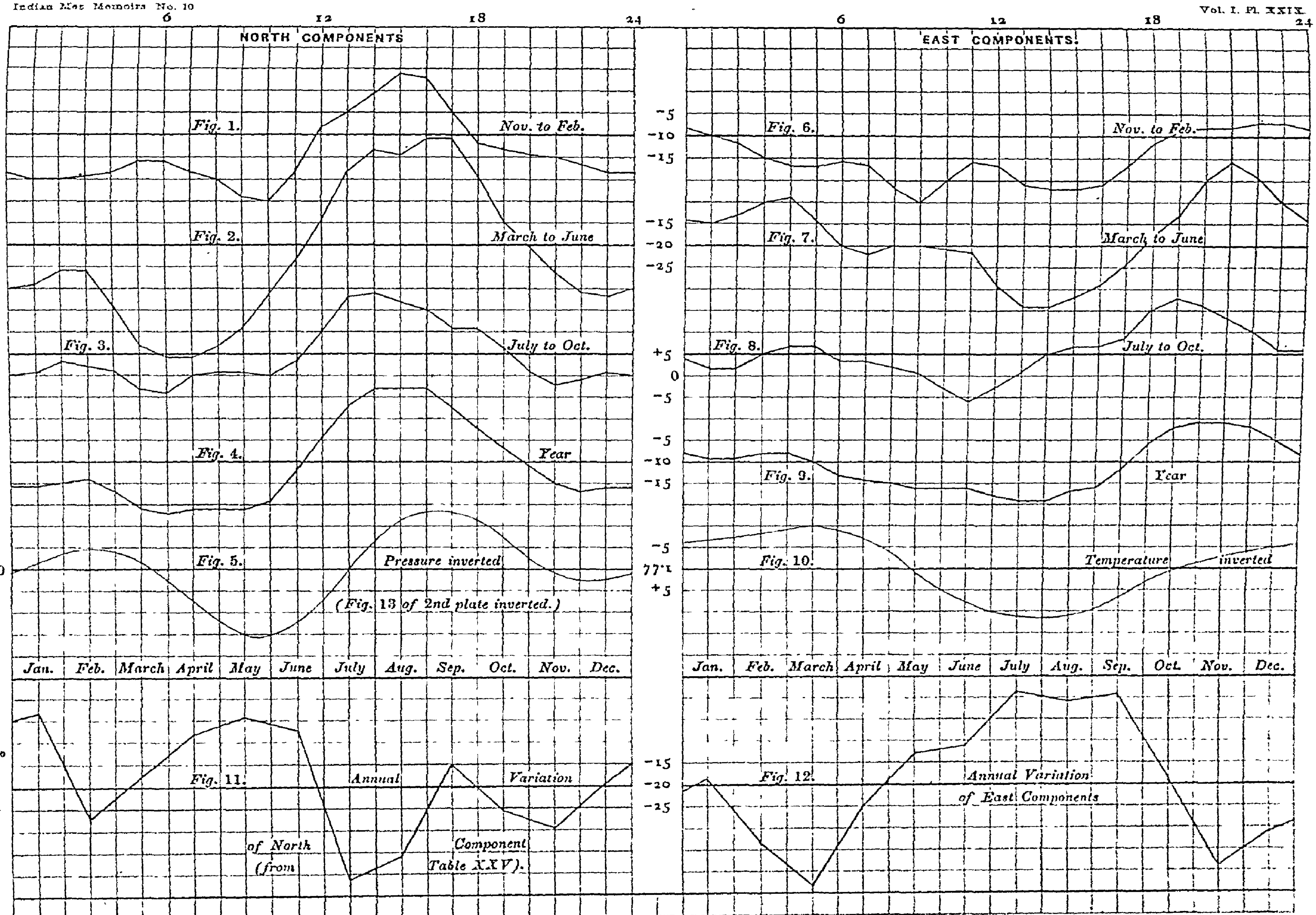
Rain is thus least probable when the wind blows from the prevailing north-west by west direction, and most likely to fall when the wind comes from the opposite quarter, that is, almost directly from the Bay of Bengal. When the wind is south-westerly, rain is much more probable than when it is either southerly or westerly. Falls of rain which accompany west or south-west winds are also distinctly heavier than those which come from the east, and much heavier than those which occur when north or south winds are blowing. These heavy falls occur chiefly in the middle of the rainy season, when there is

a slight but quasi-permanent barometric depression in South-eastern Oudh, towards which westerly winds from the Arabian sea are drawn in. This barometric depression is probably best marked in August, for there is a distinct excess of westerly winds in that month both at Allahabad and Benares.

The foregoing pages contain all the results of the Allahabad observations, that are considered worth publication at present. One of the objects, the *Indian Meteorological Memoirs* were intended to serve, was the description of local climates. The data contained in this paper are, I believe, the fullest that have ever been published for a station in the interior of India, and I hope, therefore, they will be found useful to climatologists. Some of them, especially those relating to temperature, barometric pressure and wind, may also be thought worthy of the attention of persons engaged in the investigation of meteorological problems from the point of view of Physics.

DIURNAL VARIATION OF TEMPERATURE, ALLAHABAD.





Thos. D. Bona, Sup. P.

XI.—The diurnal variation of the barometer at Indian Stations. Part II: Goalpara, Patna, and Leh. By HENRY F. BLANFORD, F.R.S., *Meteorological Reporter to the Government of India.*

In No. VI of this volume, I gave the numerical horary values of the diurnal variation of atmospheric pressure at Calcutta and Hazaribagh. The present paper contains the results of the hourly readings of the barometer at three other stations, differing greatly in the geographical characteristics of their situations, both from one another, and also from the two stations dealt with in the previous discussion. As will be seen, they exhibit corresponding differences in the character of their diurnal barometric oscillations. They are all extra-tropical; one being situated in the valley of Assam; another on the Gangetic plain, in the comparatively dry climate of Behar; and the third at an elevation of 11,500 feet in the deep Tibetan valley of the Upper Indus.

GOALPARA.—This station is situated in N. latitude 26° 11′, on the south bank of the Brahmaputra, about 30 miles above the point where the river debouches from the valley of Assam on the plains of Northern Bengal. The northern spurs of the Garo hills, which enclose the valley on the south, are distant about 16 miles from the station; and those of the Bhutan Himalaya, which flank it on the north, approach to a distance of 40 miles. The average elevation of the former hills is about 2,000 feet, and they form the western extremity of the plateau, about 60 miles in width, which divides the valley of Assam from the jhils of Silhet and the alluvial plain of the Soorma river. The observatory is situated on the summit of a little hill, 249 feet above the highest water-level of the river, and 386 feet above mean sea-level.

The climate of Goalpara is essentially mild and somewhat damp, like that of Assam generally, but less so than Upper Assam. The mean temperature of the year is 75°, that of the warmest month, August, 81·8°, and that of the coolest, January, 63°, as shown by the observations of ten years. Owing to the comparative copiousness of the spring rains, the temperature, instead of rising rapidly during the earlier months, culminating in May and falling in June, as in the drier climate of the North-Western Provinces, and even in Lower Bengal, undergoes a gradual increase during the ascent of the sun in northern declination, and does not attain its average maximum until the month of August; when the rains have so far slackened, that the mean rainfall of the month is about half that of the month of June. The hot season, as understood in Hindustan, is therefore unknown. In March, which is the driest month, the mean daily range of temperature is 23·7°, which is not much less than at many stations in Upper India; but the absolute annual range, on the mean of two years, does not exceed 50·7°, and in no single year of the decade is it higher than 56·7°; figures which may be compared with those of Patna presently to be noticed.

The mean humidity of the air of the observatory, which, as has been mentioned above, is situated on a hill, is 74 per cent. of saturation; that of the driest month

March, being 56 per cent., and that of the wettest month, June, 86 per cent. The mean vapour tension, derived from the observations of five years, is 0·669", increasing from 0·399" in January to 0·923" in July; and the average proportion of cloudy sky, derived from ten years' estimates, is 4·61 on the mean of the year, 2·62 in February, and 7·59 in June; an overclouded sky being reckoned as 10.

The hourly observations, here discussed, were commenced on the 7th July 1873, and extend over five years. They have been recorded on the 7th, 14th, 21st, and 28th of each month; and each monthly average is derived therefore from twenty series, each series beginning and ending with a midnight observation. The instrument used throughout is a small standard, on Fortin's principle, by Casella, with a tube 0·4 inch diameter; and has been compared with the Calcutta standard, to the value of which all the readings are reduced.

The computation of the probable values of the hourly variations has been carried out in the manner described in Part I of this paper, in the case of the Calcutta and Hazaribagh observations; excepting that the values of the several terms of the harmonic formula have been obtained directly from the observations, and have not been corrected as an annual series. Neither have I corrected the original values to the means of the more numerous observations, which, previous to the commencement of the hourly readings, had been recorded four times daily, at 4 and 10 A.M. and P.M. These latter observations, which extend from June 1869 to May 1873, were recorded with a mountain barometer, having a tube of about 0·25 inch diameter; and the following table shows the mean variation of the four hours of observation deduced from the four years' readings, together with those of the corresponding hours obtained from the twenty series of hourly readings. In both tables the mean of the four readings is taken as the point of departure.

Months.	From six-hourly readings.				From hourly readings.			
	4 hours.	10 hours.	16 hours.	22 hours.	4 hours.	10 hours	16 hours.	22 hours.
January	−·001	+·058	−·071	+·015	−·025	+·075	−·063	+·014
February	−·003	+·060	−·069	+·012	−·023	+·073	−·069	+·018
March	−·005	+·058	−·069	+·016	−·019	+·079	−·072	+·012
April	−·011	+·062	−·069	+·019	−·021	+·079	−·063	+·006
May	−·007	+·062	−·065	+·010	−·016	+·071	−·062	+·007
June	−·008	+·050	−·057	+·014	−·011	+·047	−·059	+·024
July	−·006	+·017	−·054	+·014	−·009	+·043	−·059	+·027
August	−·009	+·051	−·055	+·014	−·014	+·052	−·064	+·026
September	−·006	+·058	−·064	+·013	−·009	+·060	−·071	+·022
October	−·007	+·056	−·064	+·016	−·019	+·067	−·062	+·013
November	0	+·052	−·065	+·014	−·021	+·072	−·061	+·014
December	0	+·053	−·063	+·011	−·017	+·077	−·070	+·011

Excepting in the months of June and July, the range shown in the first of these tables is so much less than that shown in the second, that I have not thought it advisable to adopt the former values in preference to the latter; as was done in the

case of the Hazaribagh tables. Doubtless, the differences observable, are partly to be attributed to the inferior character of the instrument used during the first four years. But I expect also, that in these years, there has been a considerable want of punctuality on the part of the observers, more especially in the case of the night readings. The hourly readings, being recorded by two observers, who relieved each other at intervals (of 3 hours for the night observations), are evidently the more trustworthy.

Table I gives the means of each hour for each month of the year, as obtained from the readings, corrected only for the difference between the means of the initial and terminal midnight observations, which difference has been distributed equally throughout the series. This table gives also the hourly variations from the mean of the day.

Table II gives the rectangular coördinates for the first four periodic terms of the harmonic formulæ for each month and for the year; and Table III the coefficients computed therefrom. Table IV shows the hourly values for each month, computed by the several formulæ, and the corresponding curves are represented in plate XXXI; and Tables V and VI give the instants of maximum and minimum pressure, and their respective values, obtained by Jelinck's method of approximation.

TABLE I.

Mean hourly pressures and hourly variations of pressure at Goalpara. Means of twenty series of hourly readings in each month.

Hours.	January. Mean.	January. Diff.	February. Mean.	February. Diff.	March. Mean.	March. Diff.	April. Mean.	April. Diff.	May. Mean.	May. Diff.	June. Mean.	June. Diff.
Midnight	29·653	+·009	29·580	+·013	29·490	+·009	29·413	+·004	29·339	+·003	29·235	+·014
1	·650	+·006	·572	+·005	·483	+·003	·403	−·006	·326	−·010	·226	+·005
2	·642	−·002	·558	−·009	·470	−·011	·389	−·020	·321	−·015	·213	−·009
3	·632	−·012	·550	−·017	·463	−·018	·387	−·022	·314	−·022	·206	−·015
4	·620	−·024	·546	−·021	·461	−·020	·386	−·023	·321	−·015	·207	−·014
5	·626	−·018	·555	−·012	·471	−·010	·404	−·005	·332	−·004	·216	−·005
6	·640	−·004	·575	+·008	·494	+·013	·428	+·019	·356	+·020	·234	+·013
7	·662	+·018	·600	+·033	·522	+·041	·457	+·048	·381	+·045	·252	+·031
8	·688	+·044	·622	+·055	·550	+·069	·476	+·067	·399	+·063	·262	+·041
9	·714	+·070	·638	+·071	·562	+·081	·486	+·077	·408	+·072	·268	+·047
10	·720	+·076	·642	+·075	·559	+·078	·490	+·077	·408	+·072	·265	+·044
11	·698	+·054	·625	+·058	·544	+·063	·473	+·064	·396	+·060	·262	+·041
Noon	·665	+·021	·591	+·024	·516	+·035	·450	+·041	·378	+·042	·248	+·027
13	·630	−·014	·555	−·012	·478	−·003	·417	+·008	·353	+·017	·226	+·005
14	·604	−·040	·520	−·047	·444	−·037	·383	−·027	·322	−·014	·205	−·016
15	·588	−·056	·509	−·058	·420	−·061	·360	−·049	·297	−·039	·181	−·040
16	·582	−·062	·500	−·067	·408	−·073	·344	−·065	·275	−·061	·159	−·062
17	·591	−·053	·507	−·060	·409	−·072	·339	−·070	·266	−·070	·156	−·065
18	·604	−·040	·521	−·046	·420	−·061	·350	−·059	·268	−·068	·168	−·053
19	·624	−·020	·539	−·028	·438	−·043	·366	−·043	·285	−·051	·189	−·032
20	·643	−·001	·562	−·005	·466	−·015	·385	−·024	·306	−·030	·207	−·014
21	·655	+·011	·578	+·011	·484	+·003	·403	−·006	·327	−·009	·228	+·007
22	·659	+·015	·587	+·020	·492	+·011	·413	+·004	·344	+·009	·242	+·021
23	·659	+·0 5	·584	+·017	·492	+·011	·416	+·007	·346	+·010	·243	+·022
	·644	...	·567	...	·481	...	·409	...	·336	...	·221	...

Hours.	July. Mean.	July. Diff.	August. Mean.	August. Diff.	September. Mean.	September. Diff.	October. Mean.	October. Diff.	November. Mean.	November. Diff.	December. Mean.	December. Diff.	Year. Mean.	Year. Diff.
Midnight	29·217	+·014	29·284	+·019	29·371	+·021	29·500	+·008	29·606	+·007	29·650	+·010	29·446	+·011
1	·211	+·008	·275	+·010	·362	+·012	·492	0	·601	+·002	·655	+·006	·438	+·003
2	·202	−·001	·265	0	·352	+·002	·483	−·009	·592	−·007	·650	+·001	·428	−·007
3	·197	−·006	·255	−·010	·343	−·007	·479	−·013	·585	−·014	·641	−·008	·421	−·014
4	·194	−·009	·252	−·013	·341	−·009	·474	−·018	·580	−·019	·635	−·011	·418	−·017
5	·197	−·006	·258	−·007	·345	−·005	·482	−·010	·584	−·015	·637	−·013	·426	−·009
6	·212	+·009	·272	+·007	·360	+·010	·501	+·009	·602	+·003	·650	+·001	·444	+·009
7	·226	+·023	·289	+·024	·379	+·029	·524	+·032	·627	+·028	·673	+·024	·466	+·031
8	·240	+·037	·306	+·041	·399	+·049	·546	+·054	·653	+·054	·697	+·043	·486	+·051
9	·248	+·045	·316	+·051	·411	+·061	·561	+·069	·673	+·074	·725	+·076	·501	+·066
10	·246	+·043	·318	+·053	·410	+·060	·560	+·068	·673	+·074	·720	+·080	·501	+·066
11	·238	+·035	·305	+·040	·401	+·051	·544	+·052	·652	+·053	·709	+·060	·487	+·052
Noon	·219	+·016	·287	+·022	·375	+·025	·514	+·023	·621	+·022	·670	+·027	·462	+·027
13	·198	−·005	·263	−·002	·345	−·005	·480	−·012	·585	−·014	·633	−·010	·430	−·005
14	·178	−·025	·235	−·030	·315	−·035	·455	−·037	·556	−·043	·605	−·044	·402	−·033
15	·164	−·039	·216	−·049	·292	−·058	·437	−·055	·543	−·056	·587	−·062	·382	−·053
16	·144	−·059	·202	−·063	·279	−·071	·431	−·061	·537	−·062	·582	−·067	·370	−·065
17	·141	−·062	·203	−·062	·281	−·069	·435	−·057	·543	−·056	·588	−·061	·372	−·063
18	·151	−·052	·212	−·053	·290	−·060	·443	−·049	·555	−·044	·600	−·040	·382	−·053
19	·173	−·030	·229	−·036	·311	−·039	·462	−·030	·575	−·024	·610	−·030	·401	−·034
20	·197	−·006	·256	−·009	·338	−·012	·485	−·007	·593	−·006	·636	−·013	·423	−·012
21	·210	+·010	·283	+·018	·360	+·010	·500	+·008	·608	+·009	·652	+·003	·441	+·006
22	·230	+·027	·292	+·027	·372	+·022	·506	+·014	·615	+·016	·663	+·014	·451	+·016
23	·228	+·025	·291	+·026	·375	+·025	·506	+·014	·617	+·018	·665	+·016	·452	+·017
	·203	...	·265	...	·350	...	·492	...	·599	...	·640	...	·435	...

TABLE II.

Rectangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at Goalpara, computed from Table I.

Months.		U′ sin u′.	U′ cos u′.	U″ sin u″.	U″ cos u″.	U‴ sin u‴.	U‴ cos u‴.	U⁗ sin u⁗.	U⁗ cos u⁗.
January	...	−·00543	+·02633	+·01967	−·03741	−·00018	+·01019	−·00300	−·00087
February	...	−·00606	+·03200	+·01920	−·01057	+·00072	+·00620	−·00067	−·00130
March	...	−·01274	+·04001	+·02233	−·04054	+·00101	+·00317	−·00129	+·00108
April	...	−·01946	+·03940	+·02070	−·03673	+·00165	−·00001	+·00100	+·00101
May	...	−·02060	+·03930	+·02291	−·03153	+·00159	−·00150	−·00096	+·00036
June	...	−·00501	+·02832	+·02085	−·02810	−·00056	−·00512	+·00063	+·00200
July	...	+·00183	+·02697	+·01912	−·02866	−·00157	−·00257	−·00238	+·00051
August	...	+·00012	+·02861	+·02235	−·03119	−·00013	−·00134	−·00179	−·00022
September	...	−·00117	+·03540	+·02389	−·03362	−·00071	+·00118	−·00113	−·00022
October	...	−·00733	+·03168	+·01726	−·03654	+·00080	+·00159	−·00221	−·00079
November	...	−·00667	+·03016	+·01797	−·03875	+·00105	+·00775	−·00271	−·00137
December	...	−·00626	+·03422	+·02159	−·03705	−·00063	+·01039	−·00242	−·00289
Year	...	−·00734	+·03268	+·02062	−·03495	+·00021	+·00252	−·00121	−·00022

TABLE III.

Constant co-efficients of the periodical formula, computed from Table II.

Months.			Mean.	U′.	u′.	U″.	u″.	U‴.	u‴.	U⁗.	u⁗.
					° ′		° ′		° ′		° ′
January	...	...	29·627	·02688	348 21	·04227	152 16	·01050	357 23	·00312	253 50
February	...	...	·559	·03257	349 17	·04489	154 40	·00624	6 37	·00146	207 16
March	...	...	·475	·04202	342 21	·04628	151 9	·00361	16 14	·00168	309 56
April	...	...	·403	·04394	333 43	·04216	150 36	·00165	90 21	·00142	44 43
May	...	...	·322	·04437	332 20	·03897	144 0	·00477	160 32	·00103	290 33
June	...	...	·221	·02876	319 58	·03500	143 25	·00545	185 54	·00218	16 46
July	...	...	·200	·02703	3 53	·03162	145 53	·00301	211 25	·00243	282 6
August	...	...	·257	·02861	0 14	·03837	144 23	·00141	197 47	·00180	263 0
September	...	...	·344	·03542	358 6	·04125	144 36	·00138	328 58	·00115	258 50
October	...	...	·465	·03252	346 58	·04041	154 43	·00466	9 53	·00235	250 20
November	...	...	·586	·03089	347 32	·04272	155 7	·00782	7 43	·00304	243 11
December	...	...	·638	·03479	349 38	·04288	149 46	·01041	356 32	·00377	219 57
Year	...	...	·425	·03350	347 20	·04058	149 28	·00253	4 46	·00123	259 42

TABLE IV.

Hourly variation of pressure at Goalpara, computed with the constants of Table III.

Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Midnight	+·0108	+·0131	+·0093	+·0039	+·0029	+·0159	+·0172	+·0202	+·0209	+·0086	+·0097	+·0123	+·0123
1	+·0047	+·0021	+·0007	−·0061	−·0079	+·0044	+·0076	+·0089	+·0114	−·0002	+·0013	+·0062	+·0029
2	−·0029	−·0093	−·0098	−·0183	−·0178	−·0080	−·0010	−·0020	+·0011	−·0085	−·0073	−·0005	−·0071
3	−·0118	−·0177	−·0182	−·0218	−·0216	−·0156	−·0066	−·0097	−·0070	−·0144	−·0148	−·0071	−·0143
4	−·0193	−·0192	−·0193	−·0209	−·0165	−·0143	−·0079	−·0119	−·0095	−·0155	−·0183	−·0121	−·0154
5	−·0195	−·0117	−·0090	−·0049	−·0017	−·0033	−·0033	−·0066	−·0013	−·0087	−·0139	−·0114	−·0079
6	−·0069	+·0059	+·0129	+·0197	+·0190	+·0134	+·0078	+·0058	+·0092	+·0076	+·0017	−·0002	+·0084
7	+·0184	+·0308	+·0415	+·0461	+·0433	+·0302	+·0231	+·0233	+·0285	+·0313	+·0275	+·0230	+·0307
8	+·0483	+·0561	+·0675	+·0675	+·0626	+·0418	+·0375	+·0108	+·0481	+·0553	+·0554	+·0522	+·0526
9	+·0700	+·0731	+·0823	+·0785	+·0728	+·0469	+·0460	+·0518	+·0609	+·0701	+·0737	+·0750	+·0664
10	+·0729	+·0736	+·0806	+·0774	+·0720	+·0458	+·0445	+·0522	+·0618	+·0689	+·0737	+·0795	+·0666
11	+·0519	+·0557	+·0624	+·0637	+·0606	+·0394	+·0340	+·0109	+·0487	+·0508	+·0536	+·0612	+·0521
Noon	+·0226	+·0239	+·0327	+·0395	+·0409	+·0271	+·0168	+·0208	+·0247	+·0216	+·0200	+·0261	+·0265
13	−·0127	−·0125	−·0019	+·0084	+·0157	+·0078	−·0010	−·0035	−·0052	−·0100	−·0139	−·0132	−·0037
14	−·0409	−·0433	−·0318	−·0239	−·0124	−·0168	−·0260	−·0282	−·0347	−·0367	−·0415	−·0417	−·0321
15	−·0570	−·0621	−·0602	−·0506	−·0394	−·0418	−·0460	−·0491	−·0580	−·0512	−·0574	−·0623	−·0533
16	−·0605	−·0672	−·0739	−·0663	−·0607	−·0595	−·0597	−·0623	−·0711	−·0615	−·0617	−·0663	−·0612
17	−·0533	−·0605	−·0734	−·0685	−·0711	−·0639	−·0621	−·0616	−·0715	−·0585	−·0563	−·0604	−·0635
18	−·0385	−·0457	−·0601	−·0591	−·0677	−·0540	−·0514	−·0540	−·0592	−·0466	−·0431	−·0478	−·0520
19	−·0196	−·0264	−·0391	−·0425	−·0519	−·0340	−·0295	−·0331	−·0379	−·0283	−·0249	−·0308	−·0331
20	−·0017	−·0067	−·0165	−·0237	−·0292	−·0110	−·0041	−·0078	−·0129	−·0085	−·0058	−·0122	−·0118
21	+·0108	+·0095	+·0013	−·0071	−·0078	+·0081	+·0162	+·0112	+·0085	+·0073	+·0093	+·0040	+·0060
22	+·0161	+·0188	+·0114	+·0042	+·0060	+·0196	+·0259	+·0264	+·0220	+·0153	+·0163	+·0137	+·0162
23	+·0151	+·0197	+·0136	+·0081	+·0090	+·0218	+·0250	+·0275	+·0255	+·0148	+·0158	+·0158	+·0177

TABLE V.

Mean diurnal epochs of maximum and minimum pressures at Goalpara.

Months.	1st Minimum.		1st Maximum.		2nd Minimum.		2nd Maximum.	
	hrs.	mns.	hrs.	mns.	hrs.	mns.	hrs.	mns.
January	4	32	9	38	15	48	22	18
February	3	42	9	32	15	51	22	30
March	3	37	9	24	16	28	22	47
April	3	10	9	21	16	40	22	58
May	2	58	9	25	17	15	22	47
June	3	22	9	18	16	48	22	45
July	3	45	9	22	16	42	22	23
August	3	49	9	31	16	41	22	36
September	3	52	9	31	16	32	22	53
October	3	41	9	26	16	12	22	26
November	4	3	9	30	15	55	22	23
December	4	29	9	42	15	51	22	48
Year	3	40	9	28	16	26	22	41

TABLE VI.

Mean monthly and annual values of the variation of the maximum and minimum pressures at the above epochs.

Months.	1st Minimum.	1st Maximum.	2nd Minimum.	2nd Maximum.
January	−·0208	+·0743	−·0608	+·0164
February	−·0197	+·0757	−·0673	+·0203
March	−·0200	+·0837	−·0751	+·0138
April	−·0250	+·0796	−·0692	+·0081
May	−·0217	+·0738	−·0715	+·0093
June	−·0171	+·0471	−·0612	+·0222
July	−·0081	+·0466	−·0628	+·0267
August	−·0119	+·0535	−·0652	+·0284
September	−·0096	+·0631	−·0729	+·0256
October	−·0159	+·0718	−·0617	+·0160
November	−·0183	+·0763	−·0618	+·0171
December	−·0128	+·0806	−·0664	+·0159
Year	−·0158	+·0684	−·0653	+·0161

PATNA.—On the south bank of the Ganges, about 12 miles below the junction of the Sone river, in north latitude 25° 37′, and 300 miles, in a direct line, distant from the sea. The observatory is at the civil station of Bankipore, which lies beyond the western extremity of the native city, and, like the latter, on the high bank of the river. The flat Gangetic alluvial plain extends at least 40 miles in every direction around; the nearest hills being those which border the Sone valley, about that distance to the south and south-east. On the north is the river, the reticulating channels of which occupy a width of some 4 miles; and from the northern bank, the alluvial plain extends up to the foot of the Himalaya, 200 miles away.

The climate of Patna, like that of Behar generally, is essentially continental The mean temperature of the year is 77·6°; that of January (the coldest month) 61°, and that of May (the hottest month) 88·8°. The mean absolute annual range is 70°; the mean daily range of the first five months of the year from 25° to 30°; and that of the rainy months, July to September, 10° to 14°. The humidity of the air is subject to great variations: that of the driest month (April) is 44 per cent. and that of the wettest month, August, 83 per cent. of saturation; these being the average means of 4 sets of observations recorded daily at 6-hourly intervals. The mean monthly vapour tension varies from 0·350″ in January to 0·975″ in July; and the annual average proportion of clouded sky, as shown by the mean of 11 years' observations, is 4·22; that of November 1·66, and that of July 8·14.

The hourly observations, on which the following tables are based, have been recorded on the 7th, 14th, 21st, and 28th of each month, since the 7th May 1873. Six years of these have been taken, *viz.*, up to the 28th April 1879, so that each hourly mean value is derived from 24 (or, in a few cases, 23) readings. The same barometer has been in use throughout. It is one of Casella's small standards on Fortin's principle, with a tube 0·4 inch diameter, and it is suspended 279 feet above sea-level.

From 1869 to 1872, observations were recorded four times daily, *viz.*, at 6-hourly intervals, (4 and 10, A.M. and P.M.). For these hours, therefore, we have, in addition to the above, 120 sets of readings; but they were taken with a smaller and less sensitive instrument, and, moreover, there is good reason to believe that in many cases, and especially in that of the night readings, no great punctuality was observed. I have therefore not corrected the hourly series to the less trustworthy values of the earlier series; but in the table below, I give the comparable results of the two, side by side, as variations from the mean of the four readings in each case, (not the true diurnal mean):—

Month.	From six-hourly readings.				From hourly readings.			
	4 hours.	10 hours.	16 hours.	22 hours.	4 hours.	10 hours.	16 hours	22 hours.
January	−·022	+·072	−·056	+·018	−·030	+·071	−·056	+·017
February	−·021	+·066	−·052	+·014	−·025	+·070	−·058	+·013
March	−·021	+·070	−·061	+·016	−·020	+·075	−·079	+·012
April	−·020	+·069	−·065	+·021	−·014	+·074	−·065	+·009
May	−·015	+·063	−·064	+·020	−·012	+·068	−·064	+·008
June	−·020	+·054	−·055	+·024	−·009	+·053	−·061	+·019
July	−·015	+·045	−·049	+·028	−·013	+·047	−·056	+·023
August	−·021	+·049	−·052	+·025	−·017	+·053	−·061	+·024
September	−·021	+·055	−·058	+·023	−·013	+·062	−·068	+·019
October	−·022	+·054	−·049	+·016	−·021	+·063	−·054	+·014
November	−·026	+·061	−·049	+·016	−·019	+·066	−·058	+·013
December	−·023	+·068	−·050	+·019	−·018	+·069	−·059	+·010

The reduction has been effected by precisely the same methods as in the case of Goalpara, and the results are given in the following tables. The curves, corresponding to the figures of Table X, are represented on Plate XXXII.

TABLE VII.

Mean hourly pressures and hourly variations of pressure at Patna.

Mean of twenty-three or twenty-four series of hourly readings in each month.

Hours.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Year.	
	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.	Mean.	Diff.
Midnight	29·893	+·007	29·799	+·008	29·678	+·003	29·561	+·003	29·473	+·002	29·364	+·011	29·389	+·015	29·462	+·016	29·529	+·012	29·695	+·003	29·820	+·003	29·885	+·002	29·630	+·009
1	·885	−·001	·791	0	·667	−·008	·552	−·006	·461	−·010	·352	−·001	·379	+·005	·450	+·004	·521	+·004	·689	−·003	·817	−·006	·884	+·001	·621	−·001
2	·870	−·010	·782	−·009	·658	−·017	·543	−·016	·451	−·020	·342	−·011	·367	−·007	·439	−·007	·512	−·005	·678	−·014	·809	−·014	·876	−·007	·611	−·011
3	·866	−·020	·771	−·020	·652	−·023	·539	−·019	·447	−·024	·336	−·017	·358	−·016	·433	−·013	·504	−·013	·669	−·023	·802	−·021	·868	−·015	·604	−·019
4	·859	−·027	·768	−·023	·655	−·020	·545	−·013	·460	−·011	·344	−·009	·361	−·013	·429	−·017	·503	−·014	·671	−·021	·805	−·018	·867	−·016	·606	−·016
5	·867	−·019	·776	−·015	·670	−·005	·562	+·004	·470	+·008	·360	+·007	·373	−·001	·441	−·005	·516	−·001	·689	−·003	·819	−·004	·877	−·006	·610	−·003
6	·886	−·001	·795	+·004	·693	+·018	·583	+·025	·496	+·025	·375	+·022	·384	+·010	·455	+·009	·533	+·016	·708	+·016	·838	+·015	·894	+·011	·637	+·015
7	·907	+·021	·815	+·024	·713	+·038	·601	+·043	·512	+·041	·389	+·036	·398	+·024	·469	+·023	·550	+·033	·725	+·033	·858	+·035	·915	+·032	·654	+·032
8	·931	+·045	·830	+·039	·735	+·060	·617	+·059	·527	+·056	·400	+·047	·410	+·036	·484	+·039	·565	+·048	·744	+·052	·878	+·055	·935	+·052	·672	+·050
9	·955	+·069	·853	+·062	·749	+·073	·629	+·071	·539	+·068	·407	+·054	·416	+·042	·496	+·050	·577	+·060	·757	+·065	·890	+·067	·954	+·071	·685	+·063
10	·960	+·074	·863	+·072	·750	+·075	·630	+·072	·540	+·069	·406	+·053	·421	+·047	·499	+·053	·578	+·061	·755	+·063	·890	+·067	·954	+·071	·687	+·065
11	·933	+·047	·841	+·050	·734	+·059	·611	+·053	·524	+·053	·389	+·036	·410	+·036	·485	+·039	·561	+·044	·732	+·040	·869	+·046	·931	+·048	·668	+·046
Noon	·904	+·018	·815	+·024	·708	+·033	·591	+·033	·503	+·032	·373	+·020	·399	+·025	·469	+·023	·538	+·021	·704	+·012	·838	+·015	·896	+·013	·645	+·023
13	·878	−·009	·788	−·003	·678	+·003	·561	+·003	·478	+·007	·352	−·001	·378	+·004	·445	−·001	·514	−·003	·679	−·013	·809	−·014	·867	−·016	·619	−·003
14	·856	−·030	·761	−·030	·646	−·029	·534	−·024	·451	−·020	·327	−·026	·355	−·019	·422	−·024	·486	−·031	·660	−·032	·790	−·033	·846	−·037	·593	−·027
15	·840	−·046	·744	−·047	·622	−·053	·508	−·050	·429	−·042	·308	−·045	·333	−·041	·431	−·015	·462	−·055	·647	−·045	·774	−·049	·832	−·051	·575	−·047
16	·833	−·053	·735	−·056	·612	−·063	·494	−·064	·408	−·063	·292	−·061	·318	−·056	·385	−·061	·448	−·069	·639	−·054	·766	−·057	·826	−·057	·563	−·059
17	·840	−·046	·739	−·052	·609	−·066	·487	−·071	·398	−·073	·287	−·066	·314	−·060	·385	−·061	·453	−·064	·645	−·047	·773	−·050	·830	−·053	·563	−·059
18	·850	−·036	·750	−·041	·621	−·054	·499	−·059	·411	−·060	·297	−·056	·328	−·046	·395	−·051	·470	−·047	·657	−·035	·787	−·036	·844	−·039	·576	−·046
19	·865	−·021	·765	−·026	·639	−·036	·516	−·042	·429	−·042	·323	−·030	·347	−·027	·420	−·026	·490	−·027	·672	−·020	·803	−·020	·861	−·022	·594	−·024
20	[illegible]	[illegible]	·780	−·011	·658	−·017	·536	−·022	·449	−·022	·341	−·012	·363	−·011	·439	−·007	·509	−·008	·686	−·006	·817	−·006	·875	−·008	·611	−·011
21	[illegible]	[illegible]	·794	+·003	·676	+·001	·554	−·004	·466	−·005	·358	+·005	·382	+·008	·456	+·010	·523	+·006	·692	+·000	·830	+·007	·887	+·004	·627	+·005
22	[illegible]	[illegible]	[illegible]	[illegible]	·687	+·012	·568	+·010	·480	+·009	·372	+·019	·397	+·023	·470	+·024	·535	+·018	·706	+·014	·837	+·014	·895	+·012	·639	+·018
23	[illegible]	[illegible]	[illegible]	[illegible]	·683	+·008	·570	+·012	·483	+·012	·374	+·021	·399	+·025	·472	+·026	·537	+·020	·703	+·011	·832	+·009	·892	+·009	·638	+·016
Mean	[illegible]	[illegible]	[illegible]	[illegible]	·675	...	·558	...	·471	...	·353	...	·374	...	·446	...	·517	...	·692	...	·823	...	·883	...	·622	...

TABLE VIII.

Retangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at Patna, computed from Table VII.

Months.	U′ sin u′.	U′ cos u′.	U″ sin u″.	U″ cos u″.	U‴ sin u‴.	U‴ cos u‴.	U'''' sin u''''.	U'''' cos u''''.
January ...	−·00875	+·02302	+·01764	−·03593	+·00258	+·00655	−·00301	−·00152
February	−·00971	+·02633	+·01901	−·03375	+·00129	+·00499	−·00071	−·00108
March	−·01534	+·03552	+·01883	−·03723	−·00008	+·00066	−·00017	−·00013
April	−·01411	+·03930	+·01853	−·03396	+·00024	−·00238	+·00004	−·00051
May	−·01589	+·03813	+·01831	−·03252	−·00033	−·00503	+·00004	−·00108
June	−·00471	+·03260	+·01613	−·03069	−·00023	−·00519	+·00008	+·00014
July	−·00303	+·02525	+·01967	−·02721	−·00103	−·00396	+·00117	+·00029
August	−·00246	+·02642	+·02051	−·03070	−·00091	−·00205	−·00012	+·00014
September	−·00403	+·03236	+·01787	−·03393	−·00114	+·00074	+·00058	+ ·00115
October	−·00793	+·02703	+·01053	−·03161	+·00292	+·00269	−·00075	−·00013
November	−·00878	+·02875	+·01109	−·03619	+·00154	+·00361	−·00108	−·00072
December	−·00755	+·03057	+·01299	−·03523	+·00161	+·00667	−·00254	−·00094
Year ...	−·00843	+·03045	+·01683	−·03340	+·00054	+·00051	−·00054	−·00036

TABLE IX.

Constant co-efficients of the periodical formula, computed from Table VIII.

Months.	Mean.*	U′.	u′.	U″.	u″.	U‴.	u‴.	U''''.	u''''.
			° ′		° ′		° ′		° ′
January	29·863	·02463	339 11	·01003	153 51	·00701	21 30	·00340	213 26
February	·803	·02807	339 45	·03873	150 37	·00515	14 30	·00129	213 19
March	·685	·03869	336 30	·04172	153 10	·00066	353 5	·00016	201 34
April	·574	·04186	339 52	·03869	151 23	·00239	174 15	·00051	175 31
May	·475	·04131	337 23	·03732	150 37	·00504	183 45	·00108	177 53
June	·349	·03294	351 47	·03467	152 16	·00520	182 32	·00016	29 45
July	·360	·02543	353 9	·03358	144 8	·00409	194 35	·00121	76 5
August	·427	·02653	354 41	·03602	146 16	·00221	203 56	·00044	288 26
September	·516	·03261	352 54	·03835	152 14	·00136	302 59	·00129	26 48
October	·680	·02817	343 39	·03618	163 5	·00397	47 21	·00086	210 10
November	·819	·03006	313 1	·03785	162 58	·00395	22 56	·00130	236 19
December	·880	·03149	316 8	·03755	159 46	·00686	13 34	·00271	219 41
Year	·619	·03159	344 32	·03740	153 15	·00074	46 38	·00065	236 19

* The means are those of the daily observations of between 10 and 11 years, corrected to true diurnal means, with the help of the present tables.

TABLE X.

Hourly variations of pressure at Patna, computed with the constants of Table IX.

Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Midnight ...	+·0084	+·0099	+·0032	+·0043	+·0021	+·0113	+·0169	+·0167	+·0134	+·0047	+·0027	+·0016	+·0084
1	−·0015	+·0001	−·0080	−·0065	−·0106	−·0011	+·0013	+·0047	+·0040	−·0036	−·0070	−·0020	−·0023
2	−·0116	−·0106	−·0179	−·0158	−·0197	−·0114	−·0080	−·0070	−·0064	−·0154	−·0162	−·0080	−·0121
3	−·0200	−·0187	−·0222	−·0183	−·0201	−·0146	−·0148	−·0112	−·0132	−·0205	−·0195	−·0128	−·0173
4	−·0241	−·0207	−·0180	−·0117	−·0110	−·0087	−·0128	−·0141	−·0125	−·0180	−·0167	−·0138	−·0150
5	−·0199	−·0142	−·0047	+·0032	+·0054	+·0047	−·0032	−·0064	−·0026	−·0063	−·0051	−·0077	−·0018
6	−·0042	+·0016	+·0158	+·0232	+·0248	+·0218	+·0108	+·0076	+·0144	+·0130	+·0130	+·0084	+·0127
7	+·0216	+·0245	+·0396	+·0441	+·0437	+·0378	+·0247	+·0245	+·0338	+·0359	+·0358	+·0322	+·0331
8	+·0194	+·0182	+·0603	+·0610	+·0587	+·0490	+·0358	+·0398	+·0501	+·0550	+·0558	+·0563	+·0516
9	+·0 67	+·0644	+·0738	+·0705	+·0669	+·0532	+·0425	+·0494	+·0587	+·0641	+·0675	+·0706	+·0621
10	+·0684	+·0666	+·0740	+·0688	+·0660	+·0496	+·0439	+·0501	+·0574	+·0590	+·0637	+·0676	+·0609
11	+·0502	+·0527	+·0597	+·0557	+·0550	+·0387	+·0383	+·0412	+·0153	+·0109	+·0159	+·0472	+·0173
Noon ...	+·0208	+·0267	+·0310	+·0 27	+·0315	+·0211	+·0219	+·0235	+·0236	+·0147	+·0173	+·0164	+·0212
13	−·0095	−·0035	+·0024	+·0039	+·0080	−·0013	+·0041	−·0001	−·0014	−·0122	−·0124	−·0150	−·0031
14	−·0326	−·0301	−·0283	−·0254	−·0203	−·0254	−·0200	−·0250	−·0332	−·0340	−·0370	−·0390	−·0289
15	−·0458	−·0475	−·0518	−·0497	−·0449	−·0470	−·0420	−·0464	−·0558	−·0471	−·0507	−·0526	−·0453
16	−·0501	−·0541	−·0644	−·0619	−·0618	−·0609	−·0556	−·0593	−·0667	−·0510	−·0517	−·0560	−·0584
17	−·0469	−·0512	−·0615	−·0682	−·0676	−·0635	−·0574	−·0604	−·0636	−·0465	−·0487	−·0511	−·0578
18	−·0370	−·0410	−·0538	−·0602	−·0614	−·0538	−·0478	−·0494	−·0490	−·0356	−·0374	−·0394	−·0473
19	−·0218	−·0263	−·0360	−·0431	−·0447	−·0316	−·0299	−·0295	−·0282	−·0209	−·0212	−·0236	−·0301
20	−·0044	−·0098	−·0158	−·0218	−·0227	−·0118	−·0090	−·0066	−·0077	−·0056	−·0058	−·0073	−·0106
21	+·0099	+·0016	+·0010	−·0025	−·0019	+·0080	+·0095	+·0123	+·0079	+·0067	+·0071	+·0018	+·0057
22	+·0170	+·0134	+·0104	+·0094	+·0104	+·0192	+·0213	+·0237	+·0166	+·0128	+·0125	+·0106	+·0119
23	+·0158	+·0151	+·0107	+·0113	+·0112	+·0197	+·0235	+·0214	+·0181	+·0119	+·0111	+·0096	+·0153

TABLE XI.

Mean diurnal epochs of minimum and maximum pressures at Patna.

Months.	1st Minimum.		1st Maximum.		2nd Minimum.		2nd Maximum.	
	hrs.	mins.	hrs.	mins.	hrs.	mins.	hrs.	mins.
January	4	5	9	32	16	3	22	19
February	3	47	9	38	16	12	22	43
March	3	2	9	30	16	31	22	31
April	2	47	9	22	16	47	22	41
May	2	33	9	25	16	59	22	33
June	2	52	9	3	16	43	22	32
July	3	17	9	43	16	39	22	44
August	3	31	9	35	16	35	22	34
September	3	26	9	23	16	16	22	43
October	3	13	9	9	15	56	22	20
November	3	9	9	16	15	54	22	12
December	3	42	9	21.	15	53	22	19
Year	3	14	9	21	16	26	22	32

TABLE XII.

Mean monthly and annual values of the variation of the minimum and maximum pressures at the above epochs.

Months.	1st Minimum.	1st Maximum.	2nd Minimum.	2nd Maximum.
January	—·0242	+·0707	—·0501	+·0176
February	—·0210	+·0677	—·0542	+·0154
March	—·0223	+·0756	—·0660	+·0117
April	—·0185	+·0712	—·0686	+·0117
May	—·0212	+·0677	—·0677	+·0123
June	—·0147	+·0532	—·0640	+·0209
July	—·0151	+·0441	—·0582	+·0239
August	—·0152	+·0511	—·0615	+·0253
September	—·0139	+·0593	—·0673	+·0184
October	—·0214	+·0642	—·0510	+·0134
November	—·0196	+·0680	—·0547	+·0126
December	—·0141	+·0717	—·0561	+·0109
Year	—·0175	+·0632	—·0594	+·0162

LEH.—The capital of Ladák, in Western Tibet, in north latitude 34° 10′. This is the most elevated station at which a meteorological register is regularly kept in India; the observatory being 11,500 feet above sea-level. It is situated in the Upper Indus valley, which is here, for a distance of forty or fifty miles, from 6 to 8 miles across. Along the banks of the river, are numerous villages and fields, but for a mile on each side of the valley, between the fields and the foot of the mountains, is a desert waste of sand, gravel, and large boulders. The climate is comparatively mild, as contrasted with that of the high gravel plains, which form a great part of the table-land around. The town of Leh nestles under the hills north of the valley, at a distance of some four miles from the river, up a long, gentle gravelly slope, and the observatory is at the residence of the British Joint Commissioner. Behind (*i.e.*, to the north of the town) a short lateral valley leads up to the Khardong pass.

The atmosphere of Leh, although exceedingly dry, is remarkably clear and transparent; and the solar heat most intense. By simply exposing water in an ordinary quinine phial, inked on the outside and placed within a larger bottle, Dr. Cayley succeeded in making the contents boil under the action of the sun's rays, and it is not unusual for a blackened thermometer in vacuo, when exposed to the sun, to show a temperature nearly 90° above that of the air around. Doubtless the radiation is intensified by the bare rocky hills around.

The mean temperature of Leh is 39·3°[1]; that of January 16·2°; and that of July, the hottest month, 61·1°. The absolute annual range, on the mean of 5 years, is not less than 95·3°; and the absolute range recorded during the whole period, 110°; the highest temperature in July 1876, being 93°, and the lowest, in January 1878, 17·0°. The daily range averages 30°, and occasionally amounts to nearly 40°, and does not vary very greatly with the season; being, however, somewhat less in the damper spring months than at other times of year.

The mean vapour tension, as deduced from the observations of the day time only, is ·138″; and this, as compared with the tension of saturation at the mean temperature, would make the mean relative humidity 57 per cent., which is probably not far from the truth. The driest months are October and November; and the dampest January and February. These epochs coincide with those of highest and lowest atmospheric pressure respectively. The total precipitation, on the mean of four years, is only 2·36 inches per annum.

The barometric readings, here discussed, are those of four days monthly during three complete years, extending from the 7th August 1876 to the 21st July 1879, and each hourly value is the mean of 12 days' readings. The instrument used is a mountain barometer, with a tube not exceeding $\frac{1}{4}$ inch diameter; and therefore, the range shown, great as it is in certain months, is probably slightly less than would be given by a larger instrument. The curves (represented on Plate XXXIII) present the remarkable feature that, owing to the great magnitude of the diurnal fall of pressure between the forenoon and the afternoon, during six months of the year, (*viz.*, from June to November,) the oscillation is single, having but one maximum and one minimum.

The means of the hourly readings, after correcting for any difference in the initial and final midnight mean readings, have been tabulated in Table XIII, and Tables XIV to XVIII contain the results computed therefrom by the method already described in a previous paper.

[1] This is 3·6° lower than that given by Baron H. von Schlagintweit from 14 months' registers.

TABLE XIII.

Mean hourly pressures and variations of pressure at Leh.

Means of 12 series of hourly readings in each month.

Hours	January Mean	January Diff	February Mean	February Diff	March Mean	March Diff	April Mean	April Diff	May Mean	May Diff	June Mean	June Diff
	19+		19+		19+		19+		19+		19+	
Midnight	647	+ 005	585	+ 009	690	+ 014	695	+ 011	680	+ 016	667	+ 009
1	645	+ 003	584	+ 007	697	+ 011	695	+ 011	677	+ 013	668	+ 010
2	640	− 002	583	+ 006	682	+ 006	694	+ 010	676	+ 012	668	+ 010
3	638	− 004	581	+ 004	679	+ 003	691	+ 007	675	+ 011	669	+ 011
4	639	− 003	587	+ 010	676	0	692	+ 008	679	+ 015	674	+ 016
5	643	+ 01	592	+ 015	680	+ 004	696	+ 012	681	+ 017	679	+ 021
6	649	+ 007	599	+ 022	687	+ 011	701	+ 017	691	+ 027	689	+ 031
7	651	+ 010	607	+ 030	698	+ 022	708	+ 024	697	+ 033	698	+ 040
8	670	+ 028	617	+ 040	708	+ 032	715	+ 031	704	+ 040	700	+ 042
9	674	+ 032	617	+ 040	714	+ 038	718	+ 034	705	+ 041	699	+ 041
10	673	+ 031	615	+ 038	711	+ 035	718	+ 034	697	+ 033	694	+ 036
11	658	+ 016	603	+ 026	704	+ 028	702	+ 018	681	+ 017	680	+ 022
Noon	642	0	586	+ 009	690	+ 014	686	+ 002	663	− 001	665	+ 007
13	628	− 014	562	− 015	671	− 005	672	− 012	642	− 022	649	− 009
14	617	− 025	546	− 031	659	− 017	661	− 023	630	− 034	631	− 027
15	613	− 020	537	− 040	645	− 031	647	− 037	614	− 050	620	− 038
16	610	− 032	528	− 049	632	− 044	639	− 045	607	− 057	611	− 047
17	612	− 030	557	− 020	639	− 037	638	− 046	609	− 055	604	− 054
18	627	− 015	537	− 040	642	− 034	645	− 039	617	− 047	605	− 053
19	638	− 004	547	− 030	653	− 023	661	− 023	637	− 027	621	− 037
20	646	+ 004	563	− 014	659	− 017	677	− 007	652	− 012	638	− 020
21	650	+ 008	573	− 004	668	− 008	685	+ 001	666	+ 002	647	− 011
22	648	+ 006	579	+ 002	674	− 002	690	+ 006	672	+ 008	655	− 003
23	648	+ 006	582	+ 005	686	+ 010	692	+ 008	678	+ 014	659	+ 001
Mean	642		577		676		684		664		658	

Hours	July Mean	July Diff	August Mean	August Diff	September Mean	September Diff	October Mean	October Diff	November Mean	November Diff	December Mean	December Diff	Year Mean	Year Diff
	19+		19+		19+		19+		19+		19+		19+	
Midnight	622	+ 008	691	+ 017	707	+ 002	726	+ 007	736	+ 007	696	− 003	679	+ 009
1	626	+ 012	693	+ 019	712	+ 007	728	+ 009	737	+ 008	697	− 002	679	+ 009
2	630	+ 016	692	+ 018	716	+ 011	730	+ 011	735	+ 006	696	− 003	679	+ 009
3	635	+ 021	690	+ 016	721	+ 016	730	+ 011	736	+ 007	698	− 001	679	+ 009
4	639	+ 025	692	+ 018	726	+ 021	731	+ 012	738	+ 009	697	− 002	681	+ 011
5	644	+ 030	695	+ 021	734	+ 029	738	+ 019	745	+ 016	706	+ 007	686	+ 016
6	656	+ 042	701	+ 027	743	+ 038	745	+ 026	748	+ 019	716	+ 017	693	+ 023
7	661	+ 047	711	+ 037	754	+ 049	752	+ 033	757	+ 028	733	+ 034	703	+ 033
8	663	+ 049	716	+ 042	760	+ 055	760	+ 041	770	+ 041	712	+ 013	710	+ 040
9	664	+ 050	719	+ 045	764	+ 059	763	+ 044	776	+ 047	718	+ 019	713	+ 043
10	656	+ 042	715	+ 041	750	+ 045	760	+ 041	771	+ 042	746	+ 047	709	+ 039
11	639	+ 025	698	+ 024	733	+ 028	749	+ 030	760	+ 031	731	+ 032	695	+ 025
Noon	617	+ 003	672	− 002	710	+ 005	730	+ 011	737	+ 008	712	+ 013	676	+ 006
13	597	− 017	654	− 020	689	− 016	706	− 013	717	− 012	696	− 003	657	− 013
14	580	− 034	635	− 039	669	− 036	693	− 026	699	− 030	682	− 017	642	− 028
15	565	− 049	623	− 051	652	− 053	670	− 049	688	− 041	668	− 031	629	− 041
16	555	− 059	613	− 061	644	− 061	660	− 059	686	− 043	660	− 039	620	− 050
17	552	− 062	612	− 062	643	− 062	661	− 058	687	− 042	659	− 040	620	− 050
18	557	− 057	614	− 060	651	− 054	672	− 047	690	− 039	666	− 033	627	− 043
19	574	− 040	636	− 038	669	− 036	686	− 033	699	− 030	670	− 029	641	− 029
20	589	− 025	658	− 016	682	− 023	700	− 019	708	− 021	681	− 018	654	− 016
21	600	− 014	676	+ 002	691	− 014	709	− 010	719	− 010	689	− 010	664	− 006
22	607	− 007	681	+ 007	698	− 007	720	+ 001	726	− 003	692	− 007	670	0
23	616	+ 002	689	+ 015	701	− 004	725	+ 006	731	+ 002	695	− 004	675	+ 005
Mean	614		674		705		719		729		699		670	

TABLE XIV.

Rectangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at Leh, computed from Table XIII.

Months.	U′ sin. u′.	U′ cos. u′.	U″ sin. u″.	U″ cos. u″.	U‴ sin. u‴.	U‴ cos. u‴.	U⁗ sin. u⁗.	U⁗ cos. u⁗.
January ...	+·00128	+·01547	+·00343	−·01875	−·00012	+·00346	−·00125	+·00101
February ...	+·00039	+·03254	+·00827	−·01847	−·00074	+·00127	−·00067	−·00029
March ...	−·00217	+·02533	+·01200	−·01493	+·00124	+·00290	+·00006	+·00108
April ...	+·00367	+·02748	+·00877	−·01623	−·00103	+·00071	−·00208	+·00115
May ...	+·00790	+·03541	+·00819	−·01993	−·00037	+·00010	−·00138	+·00079
June ...	−·00032	+·03824	+·00811	−·01460	+·00026	−·00131	−·00129	+·00123
July ...	+·00185	+·04720	+·00668	−·01630	−·00071	+·00041	−·00142	+·00087
August ...	+·00812	+·01116	+·01161	−·02013	−·00028	+·00033	−·00308	0
September ...	−·00127	+·04706	+·00532	−·01987	−·00123	+·00182	−·00183	+·00159
October ...	+·00034	+·03797	+·01054	−·01838	−·00237	+·00134	−·00029	+·00079
November ...	−·00240	+·03293	+·00816	−·01690	+·00075	+·00124	−·00058	−·00159
December ...	−·01009	+·02897	+·00735	−·01797	+·00126	+·00244	−·00146	+·00079
Year ...	+·00062	+·03415	+·00842	−·01748	−·00034	+·00160	−·00121	+·00065

TABLE XV.

Constant coefficients of the periodical formula computed from Table XIV.

Months.	Mean.*	U′.	u′.	U″.	u″.	U‴.	u‴.	U⁗.	u⁗.
January	19·623	·01552	4°41′	·01906	169°38′	·00346	358°1′	·00161	308°56′
February	·598	·03254	0°41′	·02024	155°53′	·00147	329°46′	·00073	246°36′
March	·668	·02542	355°6′	·01915	141°13′	·00315	23°9′	·00145	41°38′
April	·662	·02772	7°36′	·01845	151°37′	·00125	304°35′	·00238	298°56′
May	·692	·03628	12°35′	·02155	157°40′	·00038	285°7′	·00159	299°47′
June	·652	·03824	359°31′	·01670	150°57′	·00134	168°46′	·00178	313°38′
July	·606	·01724	2°13′	·01762	157°43′	·00082	300°0′	·00167	301°30′
August	·648	·01196	11°10′	·02324	150°2′	·00043	319°41′	·00308	270°0′
September ...	·702	·04708	358°27′	·02037	165°1′	·00220	325°57′	·00242	310°39′
October	·732	·03797	0°31′	·02119	150°10′	·00272	299°29′	·00842	339°51′
November ...	·715	·03302	355°50′	·01877	154°14′	·00131	10°2′	·00160	200°2′
December ...	·658	·03068	340°48′	·01942	157°45′	·00275	27°19′	·00166	298°25′
Year	·663	·03416	1°2′	·01940	154°17′	·00164	318°0′	·00137	298°15′

* The means are those of the five years' (1875 79) daily observations at 10 A.M., and 4 P.M., corrected to true means. The months May, June and July 1876 being wanting.

TABLE XVI.

Hourly variation of pressure at Leh, computed with the constants of Table XV.

Hours.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Midnight ...	+·0033	+·0073	+·0120	+·0094	+·0143	+·0068	+·0065	+·0163	+·0010	+·0081	+·0060	−·0029	+·0075
1	+·0014	+·0065	+·0117	+·0100	+·0137	+·0090	+·0114	+·0170	+·0066	+·0099	+·0066	−·0022	+·0089
2	−·0007	+·0061	+·0073	+·0099	+·0129	+·0106	+·0163	+·0178	+·0120	+·0108	+·0069	−·0024	+·0095
3	−·0032	+·0069	+·0017	+·0091	+·0124	+·0124	+·0206	+·0182	+·0165	+·0116	+·0078	−·0023	+·0097
4	−·0041	+·0096	−·0006	+·0082	+·0136	+·0156	+·0250	+·0183	+·0209	+·0138	+·0095	−·0005	+·0109
5	−·0009	+·0146	+·0026	+·0100	+·0179	+·0216	+·0309	+·0203	+·0279	+·0184	+·0133	+·0060	+·0150
6	+·0073	+·0222	+·0114	+·0159	+·0257	+·0301	+·0387	+·0262	+·0382	+·0259	+·0199	+·0177	+·0230
7	+·0187	+·0314	+·0223	+·0249	+·0348	+·0388	+·0467	+·0353	+·0494	+·0346	+·0296	+·0324	+·0328
8	+·0287	+·0393	+·0316	+·0327	+·0109	+·0439	+·0515	+·0444	+·0570	+·0417	+·0100	+·0447	+·0411
9	+·0325	+·0423	+·0362	+·0349	+·0106	+·0425	+·0496	+·0466	+·0563	+·0446	+·0460	+·0497	+·0133
10	+·0279	+·0379	+·0349	+·0297	+·0324	+·0344	+·0399	+·0385	+·0458	+·0407	+·0431	+·0418	+·0374
11	+·0161	+·0257	+·0273	+·0185	+·0175	+·0217	+·0236	+·0218	+·0278	+·0296	+·0299	+·0320	+·0244
Noon ...	+·0009	+·0079	+·0140	+·0010	−·0007	+·0068	+·0041	+·0007	+·0060	+·0123	+·0092	+·0147	+·0069
13	−·0138	−·0119	−·0031	−·0110	−·0195	−·0088	−·0162	−·0200	−·0162	−·0091	−·0128	−·0030	−·0117
14	−·0253	−·0297	−·0201	−·0253	−·0365	−·0244	−·0349	−·0380	−·0364	−·0304	−·0303	−·0186	−·0289
15	−·0318	−·0125	−·0335	−·0373	−·0194	−·0390	−·0504	−·0523	−·0527	−·0478	−·0104	−·0307	−·0123
16	−·0323	−·0486	−·0400	−·0450	−·0564	−·0498	−·0600	−·0617	−·0617	−·0572	−·0135	−·0379	−·0195
17	−·0267	−·0476	−·0394	−·0454	−·0519	−·0536	−·0617	−·0635	−·0615	−·0566	−·0421	−·0396	−·0494
18	−·0167	−·0402	−·0334	−·0377	−·0449	−·0489	−·0549	−·0556	−·0524	−·0475	−·0375	−·0355	−·0422
19	−·0055	−·0284	−·0253	−·0239	−·0290	−·0374	−·0419	−·0388	−·0378	−·0334	−·0302	−·0272	−·0300
20	+·0033	−·0153	−·0168	−·0093	−·0117	−·0233	−·0269	−·0182	−·0234	−·0189	−·0210	−·0181	−·0169
21	+·0077	−·0039	−·0084	+·0017	+·0020	−·0107	−·0142	−·0002	−·0129	−·0072	−·0110	−·0107	−·0059
22	+·0077	+·0035	+·0001	+·0071	+·0104	−·0018	−·0010	+·0109	−·0070	+·0007	−·0023	−·0064	+·0012
23	+·0055	+·0069	+·0075	+·0089	+·0139	+·0035	+·0012	+·0154	−·0034	+·0054	+·0033	−·0010	+·0052

TABLE XVII.

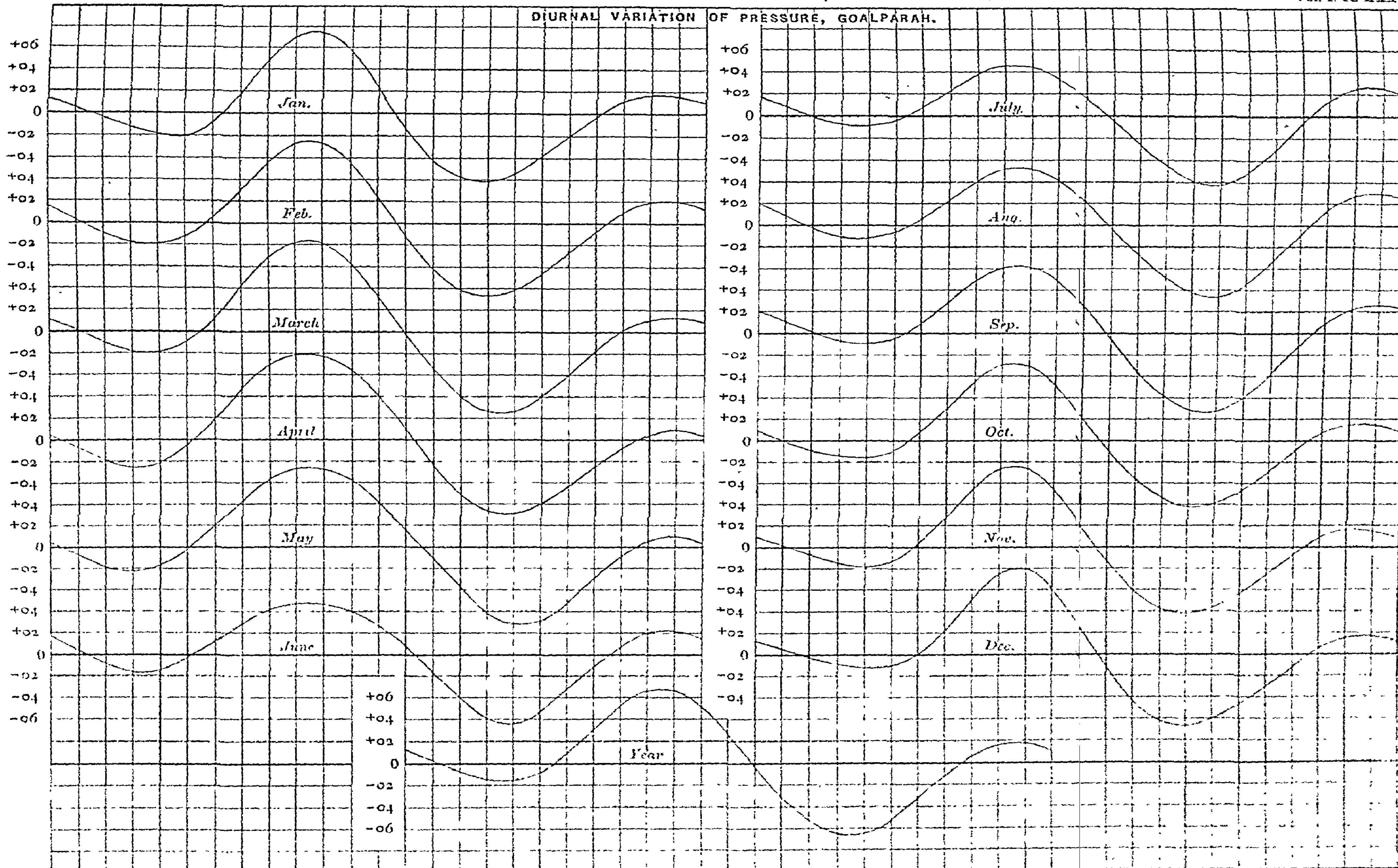
Epochs of maximum and minimum pressures at Leh.

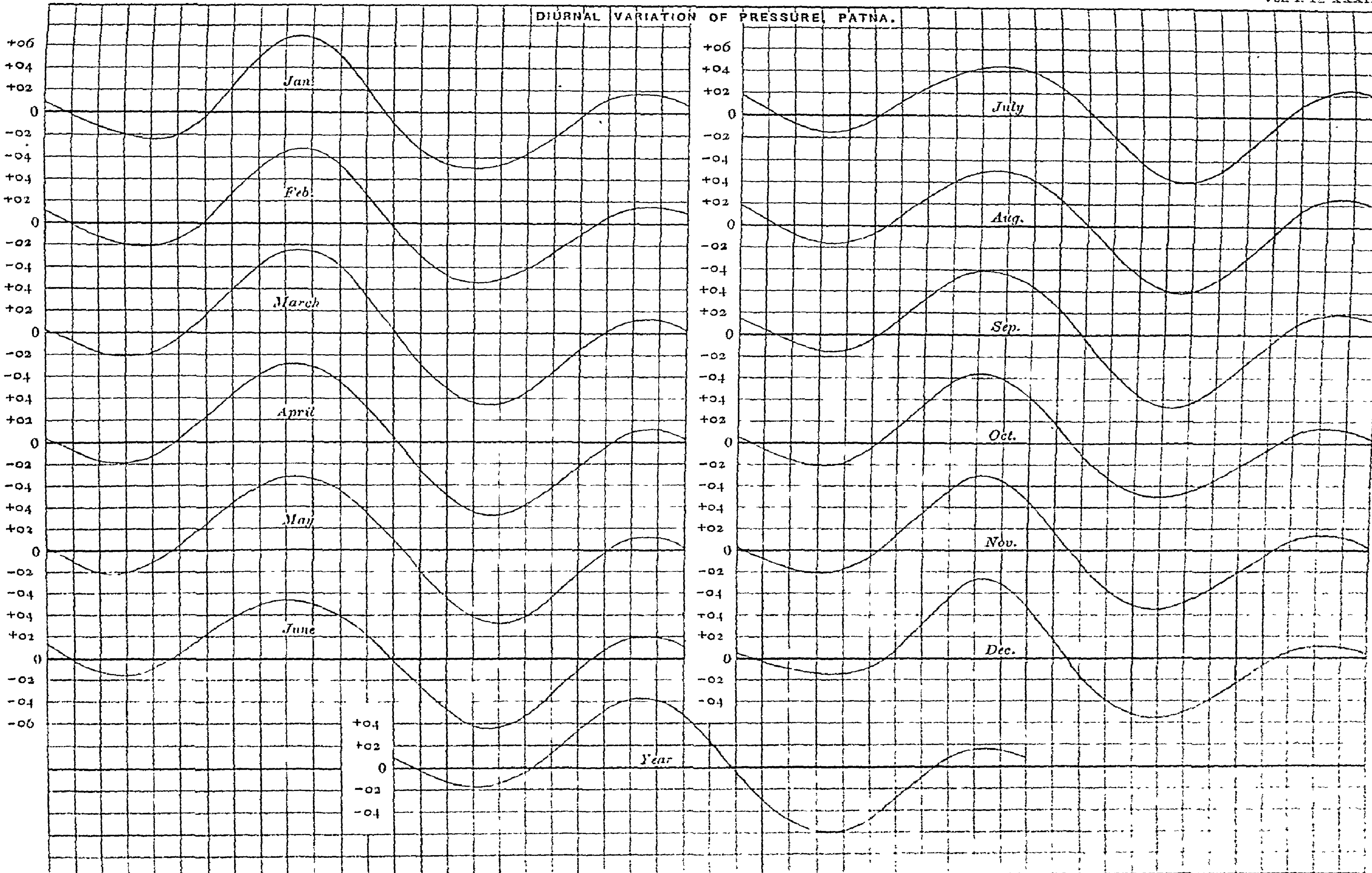
Months.	1st Minimum.		1st Maximum.		2nd Minimum.		2nd Maximum.	
	hrs.	mns.	hrs.	mns.	hrs.	mns.	hrs.	mns.
January	3	48	8	57	15	35	21	28
February	1	56	8	57	16	21	23	38
March	3	57	9	17	16	23	0	26
April	3	59	8	49	16	33	1	46
May	2	51	8	28	16	20	23	15
June	......		8	18	16	57	......	
July	......		8	16	16	42	......	
August	......		8	41	16	42	......	
September	......		8	26	16	29	......	
October	......		8	57	16	27	...	
November	......		9	14	16	7	......	
December	1	26	9	1	16	45	2	58
Year	......		8	48	16	29	.....	

TABLE XVIII.

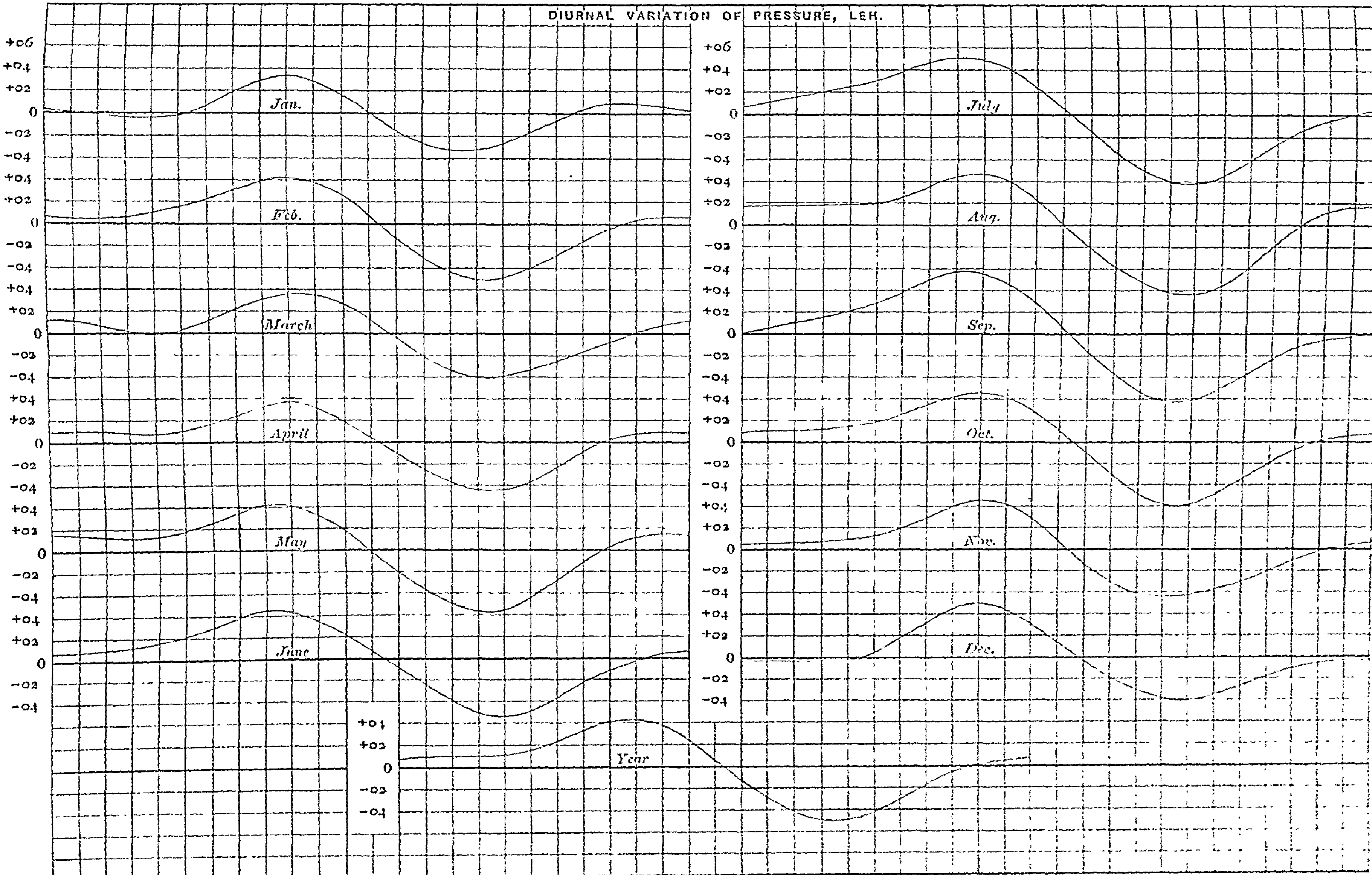
Mean monthly and annual values of the variation of maximum and minimum pressures at Leh, corresponding to the above epochs.

Months.	1st Minimum.	1st Maximum.	2nd Minimum.	2nd Maximum.
January	—·0041	+·0325	—·0328	+·0080
February	+·0061	+·0123	—·0191	+·0073
March	—·0007	+·0366	—·0401	+·0124
April	+·0082	+·0351	—·0163	+·0100
May	+·0124	+·0417	—·0567	+·0141
June	......	+·0141	—·0536	......
July	......	+·0517	—·0621	......
August	......	+·0169	—·0610	......
September	......	+·0580	—·0629	......
October	......	+·0116	—·0582	......
November	......	+·0163	—·0136	......
December	—·0022	+·0197	—·0396	—·0023
Year	......	+·0135	—·0504	......


DIURNAL VARIATION OF PRESSURE, GOALPARAH.
Jan.
Feb.
March
April
May
June
July.
Aug.
Sep.
Oct.
Nov.
Dec.
Year
+06
+04
+02
0
-02
-04
-06



Litho. T. C. Press, Roorkee
No. 1288—1.



Pho. T. C. Press, Roorkee.

XII.—*The Meteorology of the North-West Himálaya.*—*By* S. A. Hill, B.Sc., *Meteorological Reporter to Government, North-Western Provinces and Oudh.*

Prefatory Note.

The following paper was prepared to form a chapter in the volume of the *North-Western Provinces Gazetteer*, which deals with the Himálayan Districts of Kumáun, Garhwál, and Dehra Dún. Though some of the descriptions of familiar meteorological phenomena given in its pages are perhaps out of place in these *Memoirs*, the paper has been reprinted here, in order that the data contained in it may be rendered more accessible to meteorologists in general than when buried in a local gazetteer. Advantage has been taken of the reprinting of the paper to revise all the tables, and include in them, as far as possible, the results of the most recent observations. The discussion of the vertical distribution of temperature, and the annual variation of pressure has also been slightly extended.

An exhaustive discussion of the meteorology of these districts cannot yet be attempted; but sufficient data have already been collected, to serve as a basis for a general description of the climate, and at the same time to throw some light on several of the more interesting problems of meteorology. In this respect, the Himálaya, on account of its less distance from the equator and its greater elevation, presents many points of advantage, as compared with the Alps and other European mountain systems; and already some important general conclusions regarding the physics of the atmosphere have been drawn from the observations that have been made in it. The mere statement of the fact that, nearly all the snowy peaks and most of the passes over the Indian water-shed stand above the lower half of the atmosphere, and thus completely cut off all communication between India and Central Asia, except in the upper strata, indicates how much regarding the general movements of the atmosphere may be learnt from observations taken in this part of the world.

Of late years, a good deal has been done in the way of collecting trustworthy meteorological data for the mountain zone by the establishment of Government observatories at certain points. The places where observations are made at the public expense must always, however, be few, and it is desirable that more should be done in the way of enlisting the services of volunteer observers. Temperature and rainfall observations are now made at many tea-gardens in Kumáun; but, as a rule, so little attention is paid to the hours of reading, the exposure of the instruments, and the continuity of the registers, that the results are of no value for scientific discussion and comparison. By far the most important of the observations taken in the north-west Himálaya, prior to the establishment of regular observatories, were those collected by Lieutenant (now Lt.-General) R. Strachey, of the Bengal Engineers, in 1848 and 1849. Some of General Strachey's deductions from them have been given to the world in the *Proceedings of the Royal Society* and the *Journal of the Asiatic Society of Bengal*; but others have not yet been

published, though they were long ago embodied in a work on the "Physical Geography of the Himálaya" that has been placed at the disposal of the compiler of this volume. Considering the scanty nature of the materials General Strachey had to work with, the conclusions arrived at were wonderfully accurate; and though some of them were opposed to the generally received opinions of the European meteorologists of the day, they have been confirmed in almost every respect by the more extensive data subsequently obtained from the Himálayan observatories.

In the following pages a somewhat detailed discussion of all the data available for meteorological inquiry will be given after a brief general sketch of the climate. The several elements of meteorological observation will be taken in the natural order of cause and effect, commencing with solar radiation and afterwards passing on to temperature, barometric pressure and winds, and the distribution of vapour and rain.

Sketch of Climate.

The order of the three seasons on the plains of Upper India—the cold, the hot, and the rainy—is now well known even in Europe. After the close of the rains, at the end of September or beginning of October, the sky is serene and the atmosphere transparent. Owing to the absence of cloud and the rapidly diminishing proportion of water vapour, the air is also very diathermanous; that is, it permits the free passage of heat from the sun to the earth in the daytime; and in the calm nights that prevail at this season, the radiation heat into space goes on so rapidly, that the earth's surface and the air resting on it become very cold before morning. The months of October and November are thus characterized, not only by clear skies and calms, but by a great temperature range and heavy dews at night. These conditions prevail through the greater part of December, and towards the end of that month and in the beginning of January, the exposed thermometer sometimes falls 10 degrees below freezing, at places as far down the plain as Allahabad and Benares. In the Panjáb, it is much colder; and there, the shaded thermometer sometimes reaches the freezing point.

About the end of December, and in January and February, however, clouds often interfere with the free radiation of heat at night, and the daily range of temperature for these months is less, on the average, than that of November. Some rain usually falls at this time of the year, especially in the Panjáb and the higher districts of the North-Western Provinces. In March and April, the temperature rises rapidly, especially at a distance from the mountains, and the air becomes extremely dry. Hot winds, from the west or north-west, blow down the valley of the Ganges, and rapidly change the appearance of the whole country from that of a highly cultivated plain to that of a parched and sandy desert; almost the only green things left being the groves of mango trees. In April, the daily range of temperature over the plains is at a maximum, exceeding 30 degrees in most parts of the North-Western Provinces and the Panjáb. The nights are still tolerably cool; though, in the day-time, the thermometer ranges as high as 110°F. or even higher sometimes.

During May and the first half of June, the temperature continues to increase; though much less rapidly than in March and April; until, by the 15th or 20th of June, if the periodical rains have not commenced, the temperature is probably higher in North-Western India than anywhere else in the world. In the North-Western Provinces

the shaded thermometer has only been known to rise once or twice above 120°F., but in the Panjáb temperatures as high as 123° or 124° have been recorded. The days in June are thus only a few degrees hotter than those of April; but, as the rainy season approaches, the range of temperature diminishes and the nights become insufferably hot and close.

Rain seldom falls in the hot weather, the falls that do occur generally taking place during thunderstorms. About the middle of May, however, the quantity of water vapour in the air begins to increase rapidly, betokening the approach of the rainy season. This vapour is probably brought by the prevailing south-west upper current of the atmosphere, which seems to descend gradually until it merges with the surface sea winds of the Bay of Bengal and forms "the south-west monsoon" or prevailing wind of the rainy season. In Northern India, the lowest strata of the sea winds are deflected from their normal course by the mountains, and directed towards the seat of highest temperature in the Panjáb; thus appearing as east or south-east and not as south-west winds. Along the foot of the hills, these easterly winds are felt occasionally by the *middle of May, when the quantity of vapour in the air first begins to show signs of a* rapid increase.

During the latter half of June the sea winds increase in strength and gradually advance along the foot of the Himálaya, until, by the beginning of July, the rains have usually set in all over Northern India. In ordinary years rain continues to fall, not every day, but with frequent intermissions or "breaks", until about the end of September, when the easterly winds cease, except close to the hills, where they last a month longer, and are succeeded by calms or feeble currents from the west. In the Panjáb, the rains begin later, are lighter and more intermittent, and end sooner than in the North-Western Provinces; and the length and intensity of the rainy season increase regularly as we approach the sea in Bengal. During the rains, the temperature averages about 85°, over the greater part of Northern India. The daily range, at this time, varies from 8 to 16 degrees, being greatest in the driest districts.

The extremes of heat and cold are much more marked in the Panjáb and the upper part of the North-Western Provinces than in Bengal, for two reasons—the greater distance from the sea and the higher latitude. On account of its proximity to the sea and its heavy rainfall, Bengal is moist and cloudy at all seasons compared to the Panjáb. This condition of the atmosphere, by retarding the radiation of heat, renders the climate of Bengal more equable than that of the Panjáb, just as an insular climate is more equable than a continental one. Again, the latitude of the Panjáb, which is 7 or 8 degrees higher than that of Bengal, causes its winters to be much colder and its summers much hotter. At first sight it seems anomalous that a place should be the hotter the more distant it is from the equator, at any season of the year; but when it is borne in mind that the quantity of heat received from the sun is directly dependent upon the length of the day as well as on the elevation of the sun above the horizon, the anomaly disappears. Various mathematical physicists, from Halley downwards, including Poisson[1] and, more recently, Meech,[2] have calculated the total heating effect of the sun, in different latitudes, during a day or other given period of time. The latest investigation of this kind has been made by Wiener[3] of Carlsruhe, who

[1] *Theorie de la Chaleur*, 1835 edition, page 473. [2] *Smithsonian Contributions to Knowledge*, Vol. IX.

[3] *Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie*, Band XIV, page 113.

finds that, while the maximum of heat for the whole year falls on the equator, the maximum for the 21st of June is at the north pole, where the sun remains above the horizon for twenty-four hours, and has an altitude of nearly 23½ degrees for the whole of that time. In the summer half year, from equinox to equinox, most heat falls on a zone about 25½° north of the equator, and during the three months nearest to the summer solstice—that is, from the 7th of May to the 6th or 7th of August, the zone of greatest heat lies about 41°N. The total heat received, during these three months, by an area in latitude 40° or 41°N., is more than a fifth greater than that which falls on an equal area at the equator. The actual increase of temperature produced must be more than this; for the mean temperature is determined by the balance between the gain of heat during the day and the loss at night. When the gain of heat from the sun at any place is greater than at the equator, on account of the length of the day, the loss at night must be correspondingly less.

This excess of solar heat in summer, together with the dryness of the air and the absence of cloud, seems to account for the excessively high temperature of June and July in the extreme north of the Panjáb and on the plains of Yárkand and Káshgar, still farther north. In the moister zone of the mountains, the direct action of the sun is less observable; but beyond the Indian watershed it is by far the most important factor in determining the character of the seasons.

Regarding the succession of the seasons in the mountain zone, General Strachey says:—

"The same general sequence of the seasons takes place in the mountains as in the plains. Here, however, every altitude has its own special temperature, from the lower valleys where the heat is still overpoweringly great, to the regions of eternal frost; but at all elevations, in summer, the force of the sun's rays is excessive. The summer rains, too, gradually diminish in strength as we move along the chain from east to west, being at their maximum in Sikkim, but still being felt slightly on the ranges north of Peshá-war. The heaviest falls invariably take place on those portions of the chain most exposed to the south; increasing in amount up to a certain height, [not very exactly determined, but probably about 4,000 feet]; at the same time, every high and continuous ridge most sensibly diminishes the supply of rain that falls on the country to the north of it, and we find, as we approach the Indian watershed, that the quantity is very small, and that the monsoon only just drops a few partial showers on the southern border of Tibet. The winter, as may be supposed, is extremely rigorous on the summit of the table-land; and at this season, or in spring, the only important precipitations of moisture take place in the form of snow, but they are exceedingly small in quantity."

The reason why every altitude has its own special temperature is, that the air is warmed chiefly by contact with the hot ground on which it rests, and but little by direct absorption of the solar rays. The air in contact with the ground, expanding and becoming less dense, rises up; but, in doing so, its heat is rapidly converted into the work of expansion; the result being that, the temperature of the upper strata can never rise so high, on the average, as that of the air near the ground. Dry air, if heated only at the bottom, would lose 1 degree Fahrenheit, for every 183 or 184 feet of ascent. In moist air that is precipitating rain, and thus being warmed by the latent heat of the condensed vapour, the rate of decrease is much less. The rate actually observed, both in balloon

ascents and on mountain sides, is less than that calculated theoretically; because even dry air is to some extent warmed directly by the sun's rays, while air saturated with moisture has a very considerable absorbing power. On mountain slopes also, the temperature falls less rapidly than in the free air over the plains—at all events for the first nine or ten thousand feet of ascent, the reason being that the air is heated by contact with the mountain sides.

RADIATION.

No data at present exist, from which the average intensity of solar radiation, and its variations from time to time, can be estimated with any approach to exactness. Any deductions made by passing from radiation to other meteorological phenomena must therefore, to a great extent, be based on theoretical considerations.

The instrument hitherto used to measure the intensity of the sun's heat has been a maximum thermometer with a blackened bulb, surrounded by a thin glass case more or less completely exhausted of air. If the exhaustion were perfect, the temperature of the instrument would be determined by radiation to and from surrounding objects; including under these, the glass case of the instrument, which is in contact with the air, the sun, the ground, the clouds, and the open sky. Were solar thermometers all made exactly alike and exposed under absolutely identical conditions, the excess temperature of the instrument above the contemporaneous temperature of the air would be a measure of the excess of radiant heat falling on it from objects above the horizon, over that which passes away from it. The following table gives the average value of this difference for each month, at six stations. Corrections have been applied, as far as possible, for differences of instrument and exposure, except at Dehra, for which the corrections are not known:—

I.—Monthly mean excess temperature of the solar thermometer above the maximum in shade.

Stations.	Elevation in feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
		°	°	°	°	°	°	°	°	°	°	°	°	°
Leh	11,538	57·3	68·0	71·9	65·4	62·4	63·6	57.6	67·4	67·8	65·9	58·9	51·8	63·4
Chakráta ...	7,052	71·1	67·1	69·4	69·5	69·1	66·3	63·0	61·5	70·3	69 8	69·4	68·5	67·9
Ránikhet ...	6,069	61·1	60·6	62·6	60·4	60·3	57·1	50·8	52·1	59·8	57·3	52·7	55·7	57·5
Dehra ...	2,232	51·0	52·2	57·6	57·1	56·8	54·2	53·6	52·1	57·7	58·5	55·6	51·8	54·9
Roorkee ...	887	52·2	51·5	55·9	54·6	53·7	51·2	51·9	51·8	54·5	51·5	55·1	52·5	53·3
Bareilly ...	568	50·0	52·6	54·1	54·4	55·3	54·2	50 7	50 1	49·3	52·0	52·4	48·9	52·0

If the air were absolutely diathermanous, the altitude of the sun above the horizon and the vertical thickness of the atmosphere above the place of observation should have no effect upon the temperature differences in the table, which should therefore be the same for all the stations and for every month of the year. But the air having some absorbing power, the differences should be greatest when there is least air for the sun's rays to pass through; that is to say, at the highest stations and in the summer months. Up to Chakráta, the excess temperature of the solar thermometer does increase with a fair

degree of regularity; but it appears to be less at Leh than at Chakráta, contrary to all theory.[1] There is also no regular increase apparent in the heating power of the sun, as the season changes from winter to summer. The truth is that, the indications of the black-bulb thermometer are affected by so many disturbing causes, that after all possible corrections, they are of little or no value for inter-comparison; though with the same thermometer, at the same place, and under absolutely constant conditions of exposure, the figures for one year may be to some extent comparable with those for another.

The results of observations with the noctural radiation thermometer are even more unsatisfactory, owing to differences in the height of the instrument above the ground, and in the nature of the ground surface itself, whether grassy or bare.

II.—Monthly mean depression of the grass thermometer below the minimum in shade.

Stations.	January.	February.	March.	April.	May.	June	July.	August.	September.	October.	November.	December.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
Chakráta, ...	9·5	6·5	7·2	7·5	6·3	6·0	3·1	4·3	5·8	8·8	9 8	11·0	7·2
Ránikhet	14·6	13·6	13·9	13·3	12 0	9·0	5·3	6·0	8·9	13·5	17·2	19 1	12 2
Dehra	4·4	4·4	4·2	4·7	4·8	3·6	2 2	1·5	2·3	3·5	4·8	4·6	3·8
Roorkee	6 3	5 8	6·4	6·3	5·0	3 5	2·4	2·9	3·9	6·3	7·3	6·8	5·2
Bareilly	7·0	7·5	8·0	10 0	10·5	8·8	4·3	3·3	3·4	6·4	8·2	8 0	7·1

The figures in Table II serve to show that, the depression of the noctural radiation thermometer, below the minimum in shade, is less in the rainy season than in the dry, and that, both at the hill stations and on the open plain, the refrigeration of the earth surface during the night, is probably greater than at Dehra, where the observatory is situated in a well-wooded park. They do not throw any light on the question whether the air near the ground cools more rapidly at night on mountain tops or on the plains; though it is probable that in the clear, calm nights of the cold weather, the difference, if any, is in favour of the plains; since there, the air cooled by contact with the ground remains in contact with it, whereas, on the mountains, the cooled air constantly drains away, and is replaced by warmer air from the surrounding free atmosphere. This is probably the reason why nocturnal radiation appears to be less effective at Chakráta than at Ranikhet. At the former station the observatory is situated on the crest of a sharp ridge, while at the latter it is on a broad, gently sloping spur.

Temperature.

It has been already stated that, in the western Himálaya, every elevation has its characteristic mean annual temperature. Each elevation has probably also a distinctive form of variation of temperature during the year, and the daily variation is different at different altitudes, in range if not in general form.

For a proper discussion of the distribution of temperature in a hilly country a very large number of observations would in most cases be required; and these should be made at places chosen so as to be at nearly equal distances from each other vertically, and, at the same time, fairly distributed in latitude and longitude. On the southern slope of the Himálaya, it fortunately happens that differences of latitude and

[1] This is probably due to the erroneous registration of the shaded maximum thermometer, only recently brought to light.—H. F. B.

longitude make but little difference in the mean annual temperature. The sea-level values of the mean temperature at the Sub-Himálayan stations, from Lower Assám to Ambála, all lie between 76 and 78 degrees Fahrenheit, and the temperatures of places at about 7,000 feet elevation, along the whole range, from Darjíling to Marri in the north of the Panjáb, do not differ more than 2 or 3 degrees.

Both along the plains and at the level of the hill sanitaria, the highest mean temperatures are found to characterize the regions lying between the Káli and Satlaj rivers. The chief reason for the great uniformity of mean temperature, at the same elevation, that prevails over the whole Himálayan region—that is to say, through more than 7 degrees of latitude and 17 of longitude—is the greatly increased heat of summer in the north-west as compared to the east. In Bengal and Sikkim, the sun's rays, when most intense, are to a great extent cut off by cloud; whereas, in the Panjáb and the north-west Himálaya, the winter is almost if not quite as cloudy as the summer. For these reasons, Darjíling has very nearly the same temperature in January as Simla, Chakráta, or Mussooree; while, in May and June, it is seven or eight degrees cooler. The comparatively low temperature of the summer at Darjíling renders the mean for the year nearly two degrees lower than that of Marri in the extreme north-west, though the effect of latitude is apparent in the low temperature of Marri in January.

On account of this uniformity of temperature, a small number of observations, at places chosen specially with reference to height above the sea, will enable us to ascertain the most important features of temperature distribution, in the Himálayan districts of the North-Western Provinces. The following table gives the mean monthly temperatures of twenty-one places, including the two stations on the plains that were given in the previous tables. All the other places, except Dharmsála, lie in one or other of the three districts of Kumáun, Garhwál, and Dehra Dún, or in parts of Kunáwar, Lahúl, and Ladákh *to the north of* Dehra Dún. The monthly means from a Government observatory at Dharmsála in the Panjáb have been inserted, though this station lies nearly two degrees west of Dehra Dún, because it was considered desirable to have some trustworthy figures for places about 4,000 feet above the sea; and the only other station near that altitude is Háwalbágh in Kumáun, for which we have but one year's observations.

III.—Mean monthly and annual temperatures of places in Kumáun, Garhwál, Dehra Dún, and adjacent districts.

Place.	Latitude N.	Longitude E.	Elevation in feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Number of years.
BAREILLY ...	28°21'	79°27'	568	57·3°	62·6°	73·2°	83·7°	89·0°	90·3°	84·6°	84·1°	82·8°	76·4°	66·4°	58·5°	75·7°	12
ROORKEE ...	29 52	77 56	887	56·7	61·0	70·7	81·8	87·9	90·8	85·1	84·1	82·6	75·4	64·9	57·4	74·9	18
Srinagar ...	30 15	78 50	1,750	...	...	...	71·0	80·0	84·0	79·0	84·0	79·0	...	...	...	...	1
Kálsi ...	30 30	77 50	2,000?	58·3	61·0	62·6	77·7	81·2	86·0	83·7	80·2	77·2	70 8	63·2	50·7	71·8	1— 2
DEHRA ...	30 20	78 8	2,232	54·8	57·8	66·2	76·4	82·0	85·0	80·0	79·1	77·3	70·5	62·4	56·0	70·6	13
Háwalbágh ...	28 38	79 37	4,114	47·0	55·0	61·0	66·0	73·0	76·0	78·0	79·0	75·0	69·0	60·0	52·0	65·8	1
DHARMSÁLA ...	32 20	76 35	4,495	44·6	49·4	57·3	63·3	72·3	75·8	70·7	69·6	69·0	64·6	57·7	50·5	62·5	4— 5
Pauri ..	30 10	78 55	5,350	...	...	...	60·0	63·0	73·0	72·0	69·0	67·0	61·0	...	...	...	1
Almora [4] ...	29 35	79 38	5,546	46·3	52·2	57·4	64·7	70·3	75·0	73·2	72·5	72·5	65·4	57·9	51·2	63·2	6— 7

III.—Mean monthly and annual temperatures of places in Kumáun, Garhwál, Dehra Dún, and adjacent districts—continued.

Place.	Latitude N.	Longitude E.	Elevation in feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Number of years.
Lohughát ...	29°24'	80°4'	5,649	44·5°	45·8°	52·3°	60·9°	66·0°	71·0°	71·1°	70·7°	68·7°	63·1°	519°	46·4°	59 4°	2— 3
Mussooree (1) ...	30 24	78 10	5,830	45·6	47·0	57·2	63·5	67·0	70·8	66·4	65·3	65·2	63·0	56·6	47·6	59·6	1— 3
RÁNIKHET ...	29 38	79 29	6,069	46·4	48·8	57·0	65·6	67 6	71·3	67·7	67·3	66·2	61·0	55·2	49 7	60 3	10
Naini Tal ...	29 20	79 31	6,463	42 8	45·3	5·55	60·4	66·0	69·1	68·4	67·3	65·4	59·3	52·7	46 6	58·2	10
Mussooree (2) ...	30 28	78 7	6,937	41·7	44·2	51·7	59·6	65·6	68·5	64·7	64·1	63·0	57·3	52·0	46·0	56·5	3—14
CHAKRÁTA ...	30 40	77 55	7,052	42·1	43·3	51·0	59·8	64·4	67·9	64·3	64·1	62·8	57·6	51·9	46·1	56·3	11—12
Landaur ...	30 27	78 11	7,511	37·8	44·1	49·1	56·3	63·2	68·5	65·3	63·9	64·3	56 4	49·4	44·1	55·2	4— 5
Kúnam (Kunáwar)	32 0	78 30	9,296	28·8	34·6	37·2	46·6	56·7	63·7	66·6	65·0	61·3	54·1	42 6	36·1	49·4	2
Kardong (Lahúl)	32 34	77 1	10,242	24·0	36·0	44·0	47·0	49·0	54·0	63·0	60·0	52 0	46·0	37·0	27·0	44 9	1
Niti ...	30 48	79 34	11,464	...	...	...	...	...	...	58·0	58·0	55·0	...	...	...	...	1
LEH (Ladákh) ...	34 10	77 42	11,538	18·0	21·0	32·0	42·0	48·6	56·4	61·1	59·6	52·8	41·3	32·2	24·8	40 8	6—10
Spiti Valley ...	32 10	78 0	13,000	19 7	20·4	23·9	39·6	47·9	58·3	61·9	57·3	54·7	41·1	24·9	18·3	39·0	1

Authorities for the above table.

BAREILLY: Registers of the Government Meteorological Observatory, 1869 to 1880

ROORKEE: Ditto, ditto, 1863 „ 1880

DHARMSALA: Ditto, ditto, 1871 „ 1875

RANIKHET: Ditto, ditto, 1871 „ 1880

CHAKRATA: Ditto, ditto, 1869 „ 1880

LEH: Ditto, ditto, 1868 „ 1880

DEHRA: Registers of the Observatory at the G. T. Survey Office, 1868 „ 1880

NAINI TAL: Registers of Government Observatory, 1863 to 1869; and observations by Dr. Payne in 1851-54, given at page 496 of the third volume of the *Results of a Scientific Mission to India and High Asia*, by the brothers Von Schlagintweit.

MUSSOOREE (1): Records of an observatory at Saint Fidelis's School for 1877-80; somewhat fragmentary.

(2): November to April, Sir A. Waugh's and Mr. Mackinnon's observations in 1855-56, also one year's observations from Dove's tables; May to October, observations at the Survey Office for 1866-79, furnished by Mr. Hennessey, F.R.S.

LANDAUR: Registers kept at the Convalescent Hospital in 1852-54, and 1866-67. Observations for the three years 1877-79 have been communicated by the medical officer in charge, but the means deduced from them appear to be 4 or 5 degrees too high.

KALSI: Pigot—*Calcutta Journal of Natural History*, Vol. VI., 1837-38.

ALMORA: Observations at the Regimental Hospital, 1852-54 and 1866-69.

HAWALBAGH: Von Schlagintweit, page 494, on the authority of Mr. Batten; year unknown.

LOHUGHAT: Clelland's *Geology of Kumaon*, page 179: parts of 1830, 1831, 1834, and 1835.

KARDONG: Von Schlagintweit, page 513; 1855-56.

KANAM: Cunningham's *Ladak*, page 184[1]; 1827-28.

SPITI VALLEY: Ditto, page 183[2]; 1846.

SRINAGAR:
PAURI
NITI: } Manuscript observations by General Strachey and his brothers, 1847-49.

The figures for the regular meteorological observatories, (printed in small capitals in Table III) and those for the observatory at the Survey Office, Mussooree, are either directly calculated from observations at 4 A.M., 10 A.M.; 4 P.M., and 10 P.M., or have been corrected to represent the means of observations taken at these hours or the

[1] Recomputed from he maxima and minima and corrected by means of the observations of Chakrata and Leh.
he Leh observations.
[2] Recomputed and corrected by

means of twenty-four hourly observations[1]. They probably differ very little from true daily means. The mean temperatures for the other places have been calculated in various ways, and many of them are open to considerable doubt.

The mean annual temperature diminishes pretty regularly as height increases. In the table, there are only three exceptions to the rule that the higher a place is the cooler it is. It will be seen also, on comparing places of nearly equal altitude and not very far apart, that the highest temperatures belong to those which, lying behind the outermost high ridge, are subject to a much smaller rainfall than stations situated on the ridge, or in valleys opening out to the south and exposed to the full force of the rainy winds. Thus Ránikhet and Almora are too hot in comparison with Naini Tál. The difference in temperature, as well as in *humidity*, between places situated at equal heights on the outer and inner ranges of Kumáun, is sufficiently great to be easily recognisable without the aid of instruments, and is well known to all who have ever resided in the hills. The variation of temperature between the hottest and coldest months and the daily range of the thermometer are also greater, as a rule, in the interior than on the outer hills; owing to the larger proportion of cloudy sky and greater humidity of the air in the latter region.

Both the diurnal and the annual range of temperature decrease on ascending from the plains up to a height of 6,000 or 7,000 feet; and, beyond that, they again increase; their greatest values being attained at the highest stations where observations have been made. These places, however, lie to the north of the Indian watershed, where the humidity is doubtless less than on the southern side; and the observed ranges of temperature are probably higher than they would be at equal altitudes on this side of the snowy range. Moreover, the annual range, in Tibet and Ladákh, is greater than on the Indian side of the chain, on account of the difference of latitude, as has already been pointed out. In Table IV, the daily and yearly ranges of temperature at twelve places are compared, and from it these relations will be readily seen.

IV.—Mean diurnal and annual ranges of temperature at places in the Himálaya.

Place.	Diurnal Range.													Annual range of monthly means.
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Bareilly	26·3	25·5	28·0	31·0	28·3	22·1	14·2	14·2	15·0	24·3	30·4	28 0	23·9	33·0
Roorkee	26·5	24·6	28·3	31·4	28·9	22·2	14·5	14·6	17·2	27·8	32 9	29 3	24·8	34·1
Dehra	23·4	23·1	24·0	26·3	24·9	18·6	12·8	12·5	15·0	23·4	25·9	24·3	21·2	30 2
Dharmsála	15·8	18·6	20·4	21·3	21·6	18·2	12·6	12·6	15·4	19·6	20·2	18·5	17·9	31·5
Mussooree (1) ...	14·0	13·2	14·0	16·0	19·3	15·4	9·4	8·0	10·3	13·6	16·3	12·3	13·2	25·2
Ránikhet	16·1	17·0	18·2	18·6	18·1	15·0	11·2	10·9	13·1	15·3	17·2	16·1	15·5	25·1
Mussooree (2) ...	...	...		..	19·0	16·5	10·7	9·9	12 0	14·2	16·8	...	...	26·8
Chakráta	18·3	18·4	18·1	19·7	19·4	16·3	12·5	11·3	12·0	17·3	18 0	18·3	16 6	25·8
Landaur	15·3	18·7	18·2	19·7	20 0	21·2	13·1	9·5	12·2	16·5	17·0	18·2	16·6	28·8
Kanam ...	15·2	17·2	22·0	19·0	18·5	17·3	16·3	15·5	18·9	20·5	19·0	18·3	18·1	37·8
Leh	28·5	30·0	28·0	31·0	30·1	31·8	31 2	31·3	31·4	30·5	26·7	25·2	29·6	43·1
Spiti	19·3	27·7	29·2	18·5	22·0	29·0	32·1	31·3	28 4	28·0	18·0	32·2	28·7	43·6

The table shows clearly that the minimum range, for both day and year, is reached at Ránikhet and the lower Mussooree station—that is to say, about 6,000 feet above the

[1] The figures for Leh have been corrected to represent the mean of 24 hourly observations. The mean temperature of this station given by Mr. Blanford at page 371 is derived from the minimum and 4 P.M. observations, and is 1·5 too low.

sea. The dependence of the diurnal range upon the humidity of the air and the proportion of cloud at each station, is distinctly brought out in the variations from month to month. At all the stations, but Leh and the Spiti valley, which lie beyond the snowy mountains, the months of the year which are driest in India—April and May—have the largest daily thermometric range, and the most humid months—July and August—have the smallest. There is a secondary minimum of temperature range, coinciding with a maximum of humidity in January, and a secondary maximum in the dry and cloudless month of November. At Leh, where the most frequent precipitation of moisture during the year takes place in winter, the range is somewhat greater in the summer than in the winter months.

Owing to the greater annual range of temperature on the plains than on the hills, the diminution of temperature in the first 6,000 feet of ascent, is most rapid in the hottest months, and least so in the cold season. Between Roorkee and Chakráta, the difference is only 11 degrees in December and more than 23 in May. In the clear still nights of the cold weather, especially in November and December, before the winter rains and snows set in, the nocturnal loss of heat goes on almost as freely on the plains as on mountain peaks. It is thus not unusual to find the temperature of the exposed thermometer at Roorkee nearly as low as at Chakráta, and it very frequently falls lower at Roorkee than at Dehra, where the observatory is surrounded by trees. In December, the mean temperature diminishes between Roorkee and Dehra at the rate of only one degree in 1,000 feet, while, in May and June, it falls one degree in 230 feet.

The low temperature of the plains in the winter season, especially in the morning, is doubtless due, in part, to the draining of cold air down from the mountain slopes through the river gorges. This, however, cannot appreciably affect the temperature of places at a long distance from the mountains, though it may have a very considerable effect on that of Roorkee, close to the foot of the Siwáliks. The minimum temperature of the day is thus one or two degrees lower, on the average, at Roorkee, than at Dehra in the months of November and December; and in January, the minimum temperatures of the two places are equal. In the mountain country itself, it often happens, for the same reason, that the temperature of the air, at the bottom of a valley, is distinctly lower than on the adjacent ridges. A similar inversion of the normal variation of temperature with height has been noticed in Europe during calm weather in winter.

From March to June, the absorption of heat in melting and evaporating the snow on the outer hills, and in evaporating the rain that falls there in frequent showers when no rain falls over the plains, keeps down the temperature; so that, in May and the first half of June, when the plains are at their hottest, the decrease of temperature, on ascending through 6,000 or 7,000 feet, is more than twice as great as in December.

In the Panjáb, where the latitude is higher and the humidity of the air over the plains is never great, the annual range of temperature at places on the plains is higher than in the North-Western Provinces; while, in the hills, there is much less difference. The annual variation in the decrease of temperature with height is, accordingly, much more distinctly marked in the extreme west of the Himálaya, than it is in Dehra Dun. The difference of temperature between Ráwal Pindi and Marri is 19·5 degrees in July and only one-third as great in December. On the other hand, in the eastern Himálaya, where the air at all elevations up to 9,000 or 10,000 feet, is nearly equally moist, and

where the range of temperature, especially over the plain, is much less than in the north-west, the decrease of temperature with height is most rapid in February and March, and least so in June and July. The slow rate of decrement in the rainy season is doubtless due to the liberation of latent heat in the condensation of vapour; this heat rendering the atmospheric strata, in which condensation occurs, warmer than they otherwise would be, while the constant precipitation of rain prevents the lower strata from becoming very much hotter than the rain drops which pass through them. The effect of the rainy season, in retarding the fall of temperature as we ascend, is distinctly seen between Bareilly and Naini Tál or Ránikhet, but is not seen between Roorkee and Chakráta.

The great annual range of temperature at more elevated stations, especially such as lie behind the first snowy range and receive little or no precipitation, causes even greater differences in the rate of decrease of temperature with height, but in the opposite direction. In January, the difference of temperature between Chakráta and Leh is 24 degrees, but in July and August it is only 3 or 4 degrees. The greater length of the day in summer at Leh, and the absence of cloud to obstruct solar radiation on the surrounding mountain sides, render the summer months at that station, 11,500 feet above the sea, as hot as they would be, on the southern side of the snowy mountains, at an elevation of 8,500 or 9,000 feet. If General Cunningham's figures for the temperature of the Spiti valley are to be trusted, the heat of summer at an elevation of 13,000 feet is still more excessive. The relation of this to the greater height of the snow-line on the northern than on the southern side of the Himálayan system is obvious.

In the following table, the mean rate of decrease of temperature in the first 6,000 or 7,000 feet of ascent has been worked out for each month. In the Dehra Dún group, the lower station is Roorkee and the upper one Chakráta; in Kumáun, Bareilly has been taken for the lower station, and instead of choosing either Naini Tál or Ránikhet for the upper one, the monthly mean temperatures of both places have been taken and assigned to the mean elevation of the two. This was considered preferable to taking the figures for either hill station alone, because Ránikhet appears to be a little hotter than the average of places at the same elevation, and Naini Tál is probably somewhat cooler than the average.

V.—Decrement of temperature with height in the Himálaya.

Month.	Dehra Dún, difference of elevation, 6,165 feet.		Kumaun, difference of elevation, 5,695 feet.		Mean rate of decrease.	
	Difference of temperature.	Height for 1°.	Difference of temperature.	Height for 1°.	Δh for 1°.	Δt for 1,000 feet.
	°	Ft.	°	Ft.	Ft.	°
January	14·6	422	12·7	459	434	2·30
February	17·7	348	15·6	365	356	2·81
March	19·7	313	16·9	337	324	3·09
April	22·0	280	20·7	275	278	3·60
May	23·5	262	22·2	257	260	3·85
June	22·9	269	20·1	283	276	3·62
July	20·8	296	16·6	313	317	3·16
August	20·0	308	16·8	339	322	3·11
September	19·8	311	17·0	335	322	3·11
October	17·8	346	16·2	351	349	2·87
November	13·0	464	12·5	456	465	2·15
December	11·3	516	10·3	553	519	1·82
Year	18·6	331	16·5	315	338	2·96

In Dehra Dún there is a regular annual periodic variation in the rate of decrease of temperature with height, but in Kumáun, the regular variation is interrupted in July and August, when the rate of decrease is slightly retarded by the fall of rain, as has been explained above. When the mean for both districts is taken, the regular variation from month to month is only slightly broken in August.

The figures given in the table include not only the decrease of temperature due to increase of elevation above the sea, but also a certain diminution caused by an increase of latitude equal to about a degree in 6,000 feet of elevation. The change of temperature with latitude in the Himálaya is small, and to some extent masked by the contrast between the sunny valleys of the interior and the cool and cloudy outer ranges; but nevertheless it exists. On the plains of the North-West Panjáb the temperature falls as the latitude increases at a mean rate of about 1·1°F. for each degree of latitude, when corrections are made for differences of height above the sea. Probably much the same rate obtains in the western Himálaya at moderate elevations. The mean temperature of Yárkand, in latitude 39° N. and 4,200 feet above the sea, appears from the observations of Captain Trotter, R.E., and of Drs. Bellew, Henderson and Scully, to be about 54°F. At the same elevation in Kumáun the mean temperature is between 65° and 66°; and since the difference of latitude is ten degrees, the temperature appears to diminish about 1·1° or 1·2° for a degree of latitude. There is also a certain variation of the mean temperature with the longitude; places situated towards the east of the chain being cooler than those towards the west, on account of the cloudiness of the summer months. In order to determine the true variation of temperature with height, it is necessary to make allowance for these variations in latitude and longitude. The mean annual temperature of any place in the western Himálaya may thus be looked upon as a simple function of four quantities—(1) the sea-level temperature at a point taken as the zero of latitude and longitude, (2) a constant multiplied into the height of the place above the sea, (3) a constant multiplied into the latitude, and (4) a constant multiplied by the longitude. From the work of the Von Schlagintweits and the reports of the Indian Meteorological Department, fairly trustworthy mean temperatures for about thirty places in the Himálaya and Sub-Himálayan zone between the Nepál frontier and the Indus can be obtained; more than half of these being given in Table III. When treated by the method of least squares, the observations admit of being thrown into the form $T = 78{\cdot}5° - {\cdot}00277h - 1{\cdot}20\ (\lambda - 29°) - {\cdot}105\ (L - 73°)$, a formula which represents the observations with a mean error of about three-quarters of a degree. It ignores, of course, the differences of temperature between such places as Almora or Ránikhet and others of equal elevation on the outermost range. The decrement of temperature with height, when latitude and longitude remain unchanged, appears, therefore, to be 2·77 degrees in 1,000 feet, or 1° in 361 feet. In the eastern Himálaya the decrease is more rapid, the observations taken at Darjíling and Goálpára, giving a mean rate of 1° in 320 feet. At great elevations on the tableland, too, it is probable that the temperature diminishes more rapidly than on the southern slope of the mountains. General Cunningham's observations in Spiti and Rúpshu during the month of September, 1847, give a mean increase of about 280 feet in elevation for one degree of fall in temperature; and from the observations taken by Dr. Scully on the return journey from Yárkand over the Karakoram pass and through Ladákh in September, 1875, Mr. Blanford has deduced a mean fall of temperature equal to one degree in 227 feet.[1]

[1] See *ante*, page 222.

The isotherms for equal altitudes in the Western Himálaya and Ladákh, run from about N. 84° W. to S. 84° E.; being, thus, three points less inclined to the parallels of latitude than the general direction of the mountain axis; but in eastern Tibet, Nepál, and Sikhim they probably bend to the southward. The mean temperatures of Káthmandu and Darjiling, at elevations of 4,354 and 6,912 feet above the sea, appear from the observations of ten years to be 61·7 and 53·9 degrees respectively; but according to the preceding formula they should be 66·7° and 60·1°. The mean temperatures of the four stations, Darjíling, Káthmandu, Goálpára, and Sibságar, in the eastern Himálaya and Assám, may be represented very accurately by the formula $T=77{\cdot}7^\circ-{\cdot}0031h-1{\cdot}53\ (\lambda-26^\circ)-{\cdot}23(L-85^\circ)$. In this part of the chain, the temperature decreases at a mean rate of one degree in 323 feet of ascent, and the annual isotherms run from N. 80° W. to S. 80°E., the direction of the mountain axis being nearly due east and west. The isotherms are thus slightly curved, with the concavity towards the south-west, whilst the general line of the mountains is considerably curved in the opposite direction. This is merely another form of the statement in page 383, that the highest temperatures characterize that part of the chain between the Nepal frontier and the Satlaj.

Though, on the average of the year, the decrease of temperature, on ascending, is very nearly proportional to the height, it has been seen above that this rule does not apply to the individual months. In the cold weather, the variation is slow up to 5,000 feet, but becomes rapid at greater elevations; whilst in summer there is a sudden decrease of temperature on entering the mountain zone, and hardly any variation at elevations of 12,000 or 13,000 feet. The monthly mean temperatures of the group of stations lying nearly due north of Roorkee; *viz.*, Dehra, Mussooree, Landaur, Chakráta, Kánam, Kárdong, Leh and Spiti, may be approximately represented by parabolic curves, the vertex of the parabola being turned towards the axis of height in the summer months and away from it in the winter. A variation with latitude being allowed for, the general formula for the temperature of any place in this group will be $T=T_{\circ}+a(\lambda-30^\circ)+bh+ch^2$. Computing the constants from the observations of Roorkee, Dehra, Chakráta and Leh, the four stations with the longest and most trustworthy registers, and expressing *the height in thousands of feet, we get the following formulæ*:—

January	$T=57{\cdot}2^\circ-0{\cdot}84\ (\lambda-30^\circ)-0{\cdot}385h-{\cdot}236h^2$
February	$T=62{\cdot}5^\circ-0{\cdot}98\ (\lambda-30^\circ)-1{\cdot}60h-{\cdot}144h^2$
March	$T=73{\cdot}1-1{\cdot}79\ (\lambda-30^\circ)-2{\cdot}66h-{\cdot}024h^2$
April	$T=84{\cdot}0-2{\cdot}22\ (\lambda-30^\circ)-3{\cdot}33h+{\cdot}043h^2$
May	$T=91{\cdot}6-1{\cdot}48\ (\lambda-30^\circ)-4{\cdot}55h+{\cdot}117h^2$
June	$T=94{\cdot}8-0{\cdot}20\ (\lambda-30^\circ)-4{\cdot}61h+{\cdot}123h^2$
July	$T=89{\cdot}0+1{\cdot}84\ (\lambda-30^\circ)-4{\cdot}80h+{\cdot}160h^2$
August	$T=88{\cdot}1+1{\cdot}05\ (\lambda-30^\circ)-4{\cdot}53h+{\cdot}141h^2$
September	$T=85{\cdot}0-1{\cdot}59\ (\lambda-30^\circ)-3{\cdot}36h+{\cdot}100h^2$
October	$T=77{\cdot}6-2{\cdot}18\ (\lambda-30^\circ)-3{\cdot}07h+{\cdot}059h^2$
November	$T=65{\cdot}9-1{\cdot}53\ (\lambda-30^\circ)-0{\cdot}96h-{\cdot}120h^2$
December	$T=57{\cdot}4-1{\cdot}15\ (\lambda-30^\circ)+0{\cdot}002h-{\cdot}209h^2$

In July and August, there is an increase of temperature with latitude, probably greater than that due to the variation of the total heating effect of the sun; because, in these months, the plains of India and the outer slope of the Himálaya are cooled by the copious rainfall, while to the north of the snowy peaks little or no rain falls. In May and June there should, theoretically, be also a positive variation of temperature, as the

latitude increases; but the excess of solar heat which falls on the mountains as compared with the plains of India is all spent in melting the snow that accumulated during the winter; and the temperature actually diminishes as the latitude increases.

The mean temperature of any place below 15,000 feet may be computed by the preceding formulæ, with some approximation to the truth; but above 15,000 feet, the formulæ for some of the summer months give an increase of temperature with height; and these are therefore inapplicable. The monthly mean temperatures of places in the mean latitude of 32°N., at each thousand feet of elevation, are the following:—

VI.—Computed mean temperatures in Latitude 32° N., Longtitude 77° to 79° E.

Height.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Ft.	°	°	°	°	°	°	°	°	°	°	°	°	°
1,000	54·9	58·8	66·8	76·3	84·2	89·9	88·0	85·8	78·6	70·2	61·8	54·9	72·5
2,000	53·8	56·8	64·1	73·0	80·0	85·6	83·7	81·7	75·5	67·3	60·4	54·3	69·7
3,000	52·2	54·3	61·3	69·9	76·0	81·6	79·7	77·9	72·6	64·5	58·9	53·2	66·8
4,000	50·2	51·8	58·5	66·9	72·3	77·8	76·0	74·4	70·0	61·9	57·1	51·8	64·1
5,000	47·7	48·9	55·6	64·0	68·8	74·2	72·7	71·2	67·5	59·4	55·0	49·9	61·2
6,000	44·7	45·8	52·7	61·1	65·6	70·9	69·6	68·2	65·3	57·0	52·7	47·6	58·4
7,000	41·3	42·3	49·7	58·4	62·5	67·8	66·8	65·7	63·2	54·7	50·2	44·9	55·6
8,000	37·3	38·5	46·7	55·7	59·7	64·9	64·4	63·2	61·3	52·5	47·5	41·7	52·8
9,000	32·9	34·5	43·6	53·1	57·2	62·3	62·4	60·1	59·7	50·4	44·5	38·2	49·9
10,000	28·1	30·1	40·5	50·6	54·8	59·9	60·7	59·4	58·2	48·4	41·2	34·2	47·2
11,000	22·7	25·5	37·3	48·2	52·7	57·7	59·2	58·0	57·0	46·6	38·8	29·8	44·5
12,000	16·9	20·6	34·1	45·8	50·9	55·8	58·1	56·7	55·9	44·9	34·0	25·0	41·6
13,000	10·6	15·4	30·9	43·5	49·3	54·1	57·3	55·8	55·0	43·5	30·1	19·8	38·8
14,000	3·8	9·9	27·6	41·4	47·8	52·6	56·8	55·2	54·4	41·8	25·9	14·2	36·0
15,000	—3·4	4·1	24·2	39·3	46·7	51·3	56·7	54·9	53·9	40·5	21·4	8·1	33·2

It will be seen from Table VI, that, notwithstanding the extreme variation in the form of the temperature curve between summer and winter, the mean temperature of the year decreases, very uniformly, at the rate of 2·8° for 1,000 feet.

Supposing the uniform rate of decrease, worked out in Table V. to hold good for the whole southern slope of the North-West Himálaya, since the difference of latitude is nearly proportional to that of height, a mean temperature of 50° F., equal to that of London, would be attained at a height of 9,600 feet, and the annual range of temperature would probably differ little from that observed in England. The hill sanitaria, lying between 6,000 and 7,000 feet, possess climates comparable, as regards temperature, to those of Nice, Mentone, and other health resorts in the Riviera; all the towns, along the coast of France and Italy, from Marseilles to Florence, having mean temperatures between 58° and 60°F. The annual range of the monthly means, at the Himálayan stations, does not exceed 25 or 26 degrees; whereas, on the Mediterranean coast, it varies from 28 or 29 degrees at Nice, to 35 or 36 at Florence and Rome. Nice and Raníkhet have exactly the same mean temperature; but Nice is seven or eight degrees hotter than Raníkhet in July and August, and several degrees colder all through the winter and spring months, except in January, when the temperatures of the two places are nearly equal.

At the superior limit of natural forest in the Himálaya, about 12,000 feet above the sea, the mean temperature is probably nine or ten degrees above freezing. In the Alps, a species of pine, *P. cembra*, forms natural forests on the borders of perpetual snow, where the mean temperature is several degrees under the freezing point. This difference of habit between the Himálayan and Alpine pines is very curious, and it is difficult to suggest any reason for it, since the natives of the Himálaya and Tibet find little difficulty in growing poplars and fruit trees, in sheltered situations, up to 13,000 feet or higher.[1] A mean temperature of 32° would be attained at a height of 15,400 feet, which is 2,000 feet above the upper limit of cultivated trees in Tibet.

The zone which has a mean temperature of 32°, in any month, will probably be near the lower edge of the snows in that month; especially in summer, when the light falls of snow on the outer hills have been all melted away. If the height of this zone be calculated for every month, the highest value obtained will be near the perpetual snow line. With the uniform rate of decrease given in the last column of Table V., the result for July and August, when the snow-line is highest, is about 17,850 feet. This result is very much higher than that given in Humboldt's *Asie Centrale*, on the authority of some of the earliest European travellers who penetrated into the country. General Strachey has, however, shown[2] that some of these mistook the lower limit of glaciers for the line of perpetual snow. The elevations of the snow line on the Trisúl and Nanda Devi groups of peaks, determined by trigonometrical observation from Almora in the latter part of 1848, before the winter snows set in, varied, according to Strachey, from about 17,000 feet on the eastern face of each group to 15,500 on the west; this latter was, however, in part probably newly fallen autumnal snow. The conclusion from these observations was that, the height of the snow-line on the "more prominent points of the southern edge of the belt (of snowy mountains), may fairly be reckoned at 16,000 feet at the very least." The brothers Von Schlagintweit found that the average height of the snow-line, on the southern face of the Himálaya, from Bhután to Kashmir, was 16,200 feet. At page 72 of General Cunningham's book on Ladákh, the mean height of the snow-line on the peaks north of Simla, determined trigonometrically, is given at 16,665 feet, the highest point observed being about 1,000 feet higher; and in Mr. Drew's volume on the Kashmir territories, published in 1875, the elevation of the snow-line on the outermost zone is stated to be 16,500 feet. The height obtained by calculation as above suggested is thus probably a little too great, though it comes surprisingly close to some of Strachey's observations on Nanda Devi and those of Cunningham on the peaks of Kulu. Some observations have recently been made by the Trigonometrical Survey officers at Mussooree, to determine the height of the snow-line on the peaks above Jamnotri, but the results have not yet been published.

For the ranges north of Indian watershed, we have not sufficient data to calculate the approximate height of the snow-line from temperature observations; but the high temperature of Leh and the Spiti valley in July and August show most distinctly that it must be much higher than on the southern side. The limit of perpetual snow on the ridges bordering on Tibet, especially those which lie beyond the Satlaj, is given by Strachey as 19,000 feet at least. Dr. Gerard, many years ago, and more recently, Mr. Drew, assigned an elevation of 20,000 feet to the limit of the snow in Rúpshu. One reason why this limit is so high—the intensity of solar radiation in summer—has

[1] Von Schlagintweit's *Meteorology of India*, page 565.

[2] *Journal of the Asiatic Society of Bengal*, April 1849.

already been mentioned; another is the insignificant quantity of snow that falls each winter in these regions, that are almost completely cut off from the great southern vapour currents.

The lower limit of the snow in winter is usually about 5,500 feet in the outer hills of Kumáun and somewhat lower in Dehra Dún and the hills north of the Panjáb. While it lies, the temperature does not rise much above 32°; but it seldom falls in sufficient quantity to lie more than a few days at a time. About one year in ten, the snow comes down as low as 5,000 feet. The lowest level attained in the first half of the present century, was about 3,000 feet in 1817 and 1847. In 1877 and 1878, though the snow-fall was heavier than it had been for many years, it did not come down much below 5,000 feet. A slight fall of snow is said to have been observed at Lahore on the 12th of January 1874,[1] but no notice of this unprecedented occurrence was taken in the meteorological report for that month, and the correspondent who sent an account of it to the newspapers may have been drawing on his imagination.

Atmospheric Pressure and Winds.

One of the most important effects of solar heat upon the atmosphere is, to introduce disturbances in its statical pressure relations, these in turn giving rise to those movements of adjustment towards equilibrium that are recognised as winds. The diurnal heating and cooling of the air causes certain oscillatory variations of pressure called the barometric tides, and gives rise to wind movements, such as the land and sea breezes and certain mountain winds that will be described below. The great annual change of temperature between summer and winter, in like manner, causes an annual variation in the height of the barometer, and sets up those great currents of the lower atmosphere that are called the monsoons. Since the temperature is constantly changing, no such thing as a simple statical distribution of pressure ever exists, though the averages of long series of observations may approximate more or less nearly to what a statical distribution would be. The air is constantly in motion, either horizontally or vertically; and these movements cause variations of pressure, just as variations of pressure produce movements. Cause and effect, as regards pressure variations and winds, are thus so intimately mixed up, that it is next to impossible to disentangle them and show their relations clearly.

There can be little doubt that both the daily and the yearly inequality of pressure, become less as we ascend[2]; and the annual variation, at least, becomes quite altered in character at a moderate elevation; but, since the barometric variations depend upon the range of temperature, which is possibly very great at great altitudes, while at a height of 6,000 or 7,000 feet it is less than on the plains, the decrease of the pressure variations with height is not strictly proportional to that of the total pressure. Table VII gives the mean monthly pressures at a number of stations, and Table VIII the average daily range between 9-30 or 10 A.M. and 3-30 or 4 P.M. The figures for Bareilly, Roorkee, Dehra, Mussooree (upper station), Ránikhet, Chakráta, and Leh, have been corrected for the index errors of the barometers and are thus comparable with each other, except

[1] *Pioneer* (Allahabad), 17th January, 1874.

[2] This applies only to India and other countries similarly situated. In Europe and the United States the annual variation of pressure increases with the height—See *Allgemeine Erdkunde*, by Hann, v. Hochstetter and Pokorny.

in so far as the different lengths of the periods of observation may cause the averages to differ; the others involve an unknown barometer error, which does not, however, affect the range of pressure, either diurnal or annual.

VII.—Monthly and annual means of pressure at places in the Himálaya.

Place.	Elevation in feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Number of years.
		"	"	"	"	"	"	"	"	"	"	"	"	"	
Bareilly ...	568	29·117	29·366	29·263	29·148	29 033	28·924	28 933	29 002	29·100	29·265	29 308	29·112	29·188	11—12
Roorkee ...	887	29·118	29·056	28·962	28·853	28·743	28 612	28·630	28·693	28 793	28·961	29·093	29·133	28·888	13
Dehra ...	2,232	27·731	27·687	27·629	27·550	27·462	27·344	27·349	27·404	27·498	27·611	27·744	27·761	27·567	13
Dharmsála ...	4,495	25·478	25·449	25·412	25·429	25·361	25·318	25·296	25·323	25·465	25·545	25·624	25·620	25·446	2
Almora[1] ...	5,546	24·701	24·622	24·668	24·588	24·542	24·422	24·434	24·462	24·578	24·710	24·771	24·731	24·603	1
Mussooree (1) ...	5,658	24·287	24·284	24·304	24·250	24·211	24·123	24·104	24·143	24·217	24·290	24·321	24·323	24·238	1—3
Ránikhet ...	6,069	24·096	24·076	24·070	24·066	24·010	23·932	23·926	23·958	24·027	24·110	24·159	24·133	24·047	6—7
Naini Tál ...	6,463	23·865	23·834	23·858	23·832	23·760	23·687	23·693	23·716	23·758	23·879	23·905	23·894	23·807	5
Mussooree (2) ...	6,881	...	...	...	...	23·334	23·267	23·249	23·294	23·358	23·439	23·492	23 423	...	1—14
Chakráta ...	7,052	23·259	23·220	23·213	23·238	23·194	23·133	23·108	23·154	23·224	23·298	23·307	23·283	23·222	4—5
Leh ...	11,503	19·630	19·587	19·684	19·699	19·692	19·652	19·607	19·612	19·700	19·737	19·715	19 690	19·670	5—6

1 From one year's observations by General Strachey.

VIII.—Mean diurnal and annual ranges of pressure at places in the Himálaya.

Place.	Diurnal range, 10 A.M. to 4 P.M.													Annual range of monthly means.
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	
	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Bareilly	·105	·104	·107	·118	·119	·112	·096	·097	·107	·105	·108	·109	·107	·518
Roorkee	·093	·088	·089	·099	·097	·106	·083	·088	·099	·094	·091	·095	·093	·521
Dehra	·087	·087	·082	·090	·090	·086	·070	·076	·092	·092	·093	·089	·086	·420
Almora	·090	·090	·090	·090	·080	·090	·080	·080	·090	·100	·090	·100	·090	·349
Mussooree (1)	·047	·050	·041	·038	·052	·063	·045	·057	·060	·047	·042	·073	·051	·219
Ránikhet	·068	·064	·056	·060	·056	·052	·052	·055	·058	·062	·065	·060	·059	·233
Naini Tál	·066	·063	·056	·053	·054	·045	·042	·049	·058	·060	·057	·058	·055	·212
Mussooree (2)	...	...	...	...	·034	·037	·040	·044	·053	·054	·046	·049	...	...
Chakráta	·051	·050	·050	·048	·040	·039	·051	·047	·051	·055	·053	·050	·049	·199
Leh	·060	·087	·075	·075	·088	·084	·100	·101	·108	·098	·087	·083	·087	·130 / ·113

The double barometric tide that occurs regularly every day, especially in tropical countries, is still one of the least understood of atmospheric phenomena. It has been observed at all elevations in the Himálaya to which barometers have been carried, and with no considerable difference of phase,[1] though the range and general form of the oscillation are not quite the same at different heights. It is thus probably something of the nature of a wave of expansion and contraction either occurring at the same instant through the whole depth of the atmosphere or propagated upwards and downwards with a velocity equal to that of sound.

The amplitude of the daily tide bears an obvious relation to the diurnal range of temperature, for it is greater over land areas than over the sea; and in Table VIII it is seen to decrease pretty regularly from the plains up to stations situated at an elevation of 6,000 or 7,000 feet, where the range of temperature is least, becoming greater again at Leh, where the temperature range is large. Moreover, on the plains and at Leh there is a well-marked annual variation of the daily range of the barometer, having its maximum in the hot-weather months, when the temperature range is greatest, and its minimum in the rainy season or in winter. But the inequality of temperature is not the only cause on which the observed barometric tides depend; for their amplitude, as well as their general form, varies with the season, the latitude and the position of the place with respect to the sea and to mountain ranges.

The observed diurnal movements of the barometric column are in fact made up of several parts, only one of which is directly caused by the alternate heating and cooling which the air undergoes every day, though the others are all indirect effects of it. The direct effect of heating and cooling upon the pressure of the air has been more or less clearly explained by Espy, Davies, and Kreil; but it has not yet been shown by strict mathematical reasoning that their explanation accounts for the whole of the phenomenon. There is, firstly, with rise of temperature in the morning, an increase in the elastic force of the air, indicated by a rise of the barometer[2]. But the increased elastic force immediately sets up a movement of expansion, either vertically, or it may be, in some cases, laterally, by which the pressure is diminished. The actual movement of the mercury in the barometer is determined by the difference of these two actions; and consists of a rise at first, up to 9 or 10 A.M., on the average, followed by a fall which goes on until some time after the hottest period of the day. It is easily seen that, according

[1] Professor Loomis, in the *American Journal of Science* for 1879, finds that at the top of Mount Washington the daily maxima and minima set in three hours later than at the foot, though the difference of elevation between the two stations is only a little over 3,000 feet. This is quite unlike anything that occurs in the Himálaya, and is doubtless due to other causes than those which produce the diurnal tides. Hourly observations made in India show that up to a certain moderate elevation the daily barometric maxima and minima are slightly retarded; but this is due to the mountain winds described below. At Leh, in the upper Indus valley, the diurnal winds cause the morning maximum to occur nearly an hour earlier than on the plains. This will be seen from the following table :—

Place.	Height.	Morning maximum.		Afternoon minimum.	
	Feet.	H.	M.	H.	M.
Calcutta	18	9	35	16	26
Allahabad	307	9	34	16	30
Hazaribagh	2,010	9	47	16	24
Simla	7,071	10	26	16	51
Leh	11,503	8	48	16	29

[2] Modern physical doctrines, founded on laboratory experiments, assume that, in a free atmosphere, anything more than an infinitesimal increase of pressure would be at once relieved by expansion upwards. To produce a sensible increase of elastic force, a certain resistance in the upper atmosphere would be required. On this point, see Blanford, *Indian Meteorologists' Vade-Mecum*, page 187.

to this theory, as long as the temperature continues to rise more and more rapidly, that is, up to 9 A.M., or a little after, the first effect must outweigh the second, and the barometer will rise; but as soon as the rate of increase of temperature begins to grow less, expansion will prevail and the barometer will fall. The expansion will not cease at the instant when the temperature reaches its maximum, but owing to the accumulation of motion it will go on for some time longer. Thus, there ought to be a barometric maximum about the time of most rapidly increasing temperature and a minimum in the afternoon. In much the same way it can be shown that there should be a maximum in the evening, when the temperature is falling most rapidly, and a minimum about the coldest time of the morning.

The coincidence between the barometric minima and the extremes of temperature is usually very far from exact, the barometer in this country standing lowest in the mornings about two hours before the time of minimum temperature, and in the afternoon about an hour and a half or two hours after the hottest time of the day. This may perhaps be explained on the principle of forced oscillations, that in the successive transformations which the energy undergoes, the oscillations approximate more and more nearly to simple harmonic waves with the maxima and minima separated by equal intervals. The diurnal curve of temperature approaches more nearly to a simple wave form than that of the solar radiation which falls upon the earth at any place; and the double daily oscillation of pressure can be almost exactly represented by two waves superimposed.

At most places in India and the Himálaya, the minimum temperature of the day occurs about sunrise; that is to say, at 6 A.M. on the average of the year, and the maximum is attained about 2 P.M. The daily rise of temperature, therefore, occupies only eight hours of the twenty-four, and the fall the remaining sixteen. On the principle that the height of the barometer varies with the rate of change of temperature, the morning maximum should be much more decided than that of the evening; and this is found by observation to be the fact; especially in the interior of India and other continental countries. Over the sea, in tropical regions, the periods of increasing and decreasing temperature are probably more nearly equal; and there, the difference between the day and night waves of pressure is less.

At places near the equator, the epochs of maximum and minimum pressure hardly vary from month to month; but in higher latitudes, the morning maximum and afternoon minimum approach each other when the days are short, and become more widely separated in the long days of summer.

Besides this primary oscillation of pressure, caused by the heating and cooling of the air every day, the barometer indicates other changes, due to the transfer of air, by winds blowing to and from the place of observation; and perhaps also in some places it indicates other changes again, due to the repetition of previous oscillations in the form of free waves. The great regularity and considerable range of the barometric tides over tropical seas, where the daily range of temperature is small, may be thus to some extent caused by the repetition of the waves of previous days. In high latitudes, where the days and nights are usually of very unequal length, and the variation of temperature is irregular, the tides become fainter, and near the pole disappear altogether; for in forced vibrations of any kind, regular periodicity in the cause is an essential condition.

Near the coast, the land and sea breezes modify the form of the diurnal pressure curves, both at sea and on land. The transfer of air from sea to land during the earlier hours of the night renders the nocturnal fall of pressure on land less, and at sea greater than it would otherwise be; while the land breeze, which blows in the forenoons, has a similar effect in the opposite direction. Over the water, the morning minimum thus comes to be nearly as low as that of the afternoon. Among the mountains, a very similar semi-diurnal transference of air takes place, causing two distinct types of barometric tides,—the one characteristic of valleys and the plains near the mountain system, and the other of high ridges and detached peaks. These types can be readily distinguished in the following table, which gives the variations from the daily mean[1] at the hours nearest the turning points of the tides:—

		4 A. M.	10 A. M.	4 P. M.	10 P. M.
		"	"	"	"
Bareilly	...	—·021	+·060	—·047	+·008
Roorkee	...	—·020	+·057	—·036	—·001
Ránikhet	...	—·025	+·041	—·018	+·013
Naini Tál	...	—·028	+·043	—·012	—·003
Chakráta	...	—·023	+·034	—·016	—·001
Simla[2]	...	—·048	+·062	—·034	+·020
Leh	...	+·011	+·037	—·049	+·001

At Bareilly and Roorkee, on the plains, the variation from the mean at 4 P.M. is twice as great as at 4 A.M. At all the Himálayan stations except Leh, which is in a valley between two ridges, this relation is reversed. Over the plains and on the outer hills, as at Naini Tál and Chakráta, the pressure at 10 P.M. hardly differs from the mean of the day. There is a small positive variation for this hour at Bareilly, and as we recede from the mountains and approach the sea, the variation becomes greater; but there can be little error in concluding from the above table that along the southern border of the Himálaya the pressure rises in the evening just sufficiently to touch the mean. At Simla and Ránikhet, some thirty or forty miles in towards the centre of the mountain system, there is, however, a well-marked evening maximum. This seems to indicate that the air continues to accumulate over the interior of the mountain zone, for some time after the current has changed on the outer ranges, and the air has commenced to flow back towards the plains.

The transfer of air from the plains to the mountains in the daytime and its retransfer to the plains at night, which, by partly counterbalancing the afternoon fall of the barometer in the mountains and correspondingly increasing it on the plains, cause the peculiarities of the pressure variations seen in the preceding table, are brought about by the expansion and contraction of the air under the influence of heat and cold. In the daytime, the air over the plains expands more than that over the hills, because the total thickness of air is greater and the range of temperature is probably higher. The surfaces of equal pressure, which we may assume to be horizontal on the average, are thus raised more above the plains than on the mountains; and the air, under the influence of gravity, flows down the incline towards the mountains. At night, the air con-

[1] The means adopted are those of observations at 4 and 10, A.M. and P.M.

[2] From General Boileau's observations in 1843—45. The daily range given by these figures is nearly twice as great as that of the other stations at the same altitude. The reason is probably some difference in the form of the barometer or in the mode of applying the correction for capillarity.

tracts, and these surfaces sink more above the open plains than in the hills; and there is thus a slope or gradient in the opposite direction.

The following is General Strachey's description of the diurnal variation of the wind in Kumáun:—

"At most seasons of the year, we find that, on the Himalayan slope, winds blow up the valleys during the day, that is, from about 9 A.M. to 9 P.M., and down them during the corresponding hours of the night, or from 9 P.M. to 9 A.M. At the debouches of the principal streams in the plains, these night winds blow downwards with great violence, particularly in winter. In the interior of the mountains they are more moderate; and at great elevations, and in the central parts of Tibet, the nights are almost always nearly calm. The diurnal currents from the south, on the other hand, increase in force as we ascend in height; and along the Indian watershed and the neighbouring parts of Tibet, they are excessively strong; so that, in travelling there, I have often looked forward to the afternoon, when they are at their height, with real dread; and the natives of the country invariably endeavour to cross the high passes of the Indian watershed early in the day, for the purpose of avoiding the fury of the afternoon wind. As we advance further into the tableland, however, their power rapidly ceases.

"These winds, though, on the whole, blowing from the south-west during the day and from the north-east at night, that is, perpendicular to the general line of the mountains, are naturally constrained to follow the course of the deep valleys up which they pass, so that their direction is subject to endless local variation; and excepting on the tops of the hills, little information can be obtained by a register of the direction of the wind on the Himálaya, beyond the fact of there being an up or down current. In the part of Tibet I visited, near the Indian watershed to the north of Kumáun, the day wind seemed to commence in the south-east quarter about 9 A.M., and gradually to shift round with the sun as the day advanced, ending in the south-west quarter about 9 P.M. On several occasions in these localities, I also noticed the wind blowing faintly from the north early in the morning. * * * * * * * * * *

"The calm nights of the tableland and the higher mountains would [according to the theory above stated] be a consequence of their position in the centre of the mountain area, where the down current would originate, and therefore have the least force, though it be still felt in the faint northerly winds that are often observed near the Indian watershed.

"The violent night winds from the gorges by which the principal rivers leave the mountains would not appear to be altogether due to the same cause which produces the ordinary down winds, but to the accumulation of cold air in the deeper valleys to which I have before alluded. The air collected in these aërial lakes, as they may be called, having no means of escape but the openings through which the drainage is carried off, pours from them in a current the velocity of which will be dependent on the depth and area of the mountain basin from which it flows."

General Cunningham also states that, in Ladákh and Spiti, the southerly or south-westerly day wind usually begins about 9 A.M., the wind blowing faintly from the north about midnight and from the north-east in the early morning.

The day and night winds are probably strongest about 4 P.M. and 4 A.M.; and the pressure and temperature observations, made at these hours on the plains and at the hill stations, indicate, clearly enough, that the direction of the baric gradient is from the

plains towards the mountains in the afternoons, and from the mountains towards the plains in the mornings. When the pressures of Roorkee and Bareilly at 4 A.M. are reduced to the level of Chakráta and Ránikhet respectively, and are corrected for any residual gradient to or from the mountains, discovered by similarly reducing the mean pressures to the level of the hill stations, it is found that there is a pressure difference of ·077″ at Chakráta and ·055″ at Ránikhet, sending a wind towards the plains. At 4 P.M. the gradient is towards the hills, and is equal to ·062″ at an elevation of 7,000 feet, between Roorkee and Chakráta; while between Bareilly and Ránikhet it is equal to ·015″ on the average of the year. On the southern border of the mountain zone, the gradient causing the down wind at night is therefore rather greater than that which causes the up wind during the day.

When the pressures of Roorkee at 4 A.M. and 4 P.M. are reduced to the level of Leh, a station beyond the Indian watershed, the gradients are found to be ·033″ in the morning and ·182″ in the afternoon. The pressure difference causing the day wind at great elevations thus appears to be nearly six times as great as that which causes the night wind; but this relation is much exaggerated, no doubt, by the peculiar form of the pressure variation at Leh, which cannot be taken as a typical mountain station. This peculiar variation is doubtless due to the position of Leh in a narrow valley between two parallel mountain ranges. In the daytime, the air of the valley expands and flows towards the mountains, and at night it again accumulates over the valley. In this way the nocturnal barometric tide is completely obliterated during several months of the year, and the afternoon fall of the barometer is rendered much greater than it would be on an open plain or detached peak at the same altitude.[1]

In April, May, and June, the afternoon winds of the mountains blow with greatest violence, because in these months the range of temperature both on the plains and among the mountains is greatest. In these three months, we find the afternoon fall of the barometer on the plains at a maximum; while, at the hill stations, it is less than in the cold weather. The nocturnal inequality of pressure is then at a minimum on the plains and valleys and at a maximum on the hills.

The annual variation of pressure differs from the diurnal in that no part, or an exceedingly minute part of it, is due to direct increase or decrease of elastic force accompanying gain or loss of heat. The rise of temperature in the first half of the year and the fall in the latter half are accomplished so slowly, that the increase or decrease of elastic force cannot accumulate, but is lost in expansion or contraction. The annual variation is thus almost entirely a secondary effect, due to the movement of air both vertically and horizontally. When the temperature of the air over India changes, the air expands or contracts, and the hypothetical surfaces of equal pressure widen out or come closer together than they were before; and since the annual variation of temperature over the south of India is very small in comparison with that which occurs over the northern plain and in Central Asia, the vertical range through which these surfaces travel in the course of a year will be greater on the Himálaya than under the equator. In the cold weather, for example, the planes of 30, 29, 28 inches, &c., are wider apart vertically over Ceylon than in Northern India, while at the end of the hot season, and in the rainy season, the opposite relation obtains.

If there were no lateral movements of the air, the pressure at a station on the plains would be nearly constant all the year round; while, at the hill stations, it would be least

[1] See *ante*, page 375.

in winter and greatest in summer; because, in the latter season, a larger fraction of the total atmosphere than usual would be elevated above the place, while in the winter less than the average would lie above it. In winter, however, the planes of equal pressure in the upper regions of the atmosphere over India all slope towards the north, and down this slope winds blow, causing an accumulation of air over Northern India which renders the total pressure observed on the plains, at that season, greater than in summer. As regards mountain stations, it depends entirely on the height of the place, whether the influx of air from the south will be more or less than sufficient to compensate for the contraction and sinking of the atmosphere in winter. At all the hill stations in Table VII, above 5,000 feet elevation, there are indications of a winter minimum of pressure, though this is not the lowest minimum, except at Leh, the most elevated station of all. There, the pressure is least in the beginning of February; whereas, at all the other stations, as on the plains, it is least in June and July.

During the cold weather, winds are usually blowing out from Northern India towards the south, along the surface of the ground, at the same time that other currents are blowing northward in the upper strata; the apparent direction being modified, in either case, by the rotation of the earth on its axis and by friction against the ground surface. On the plain of the Ganges, the conformation of the surface makes the lower winds have a north-westerly direction.

As the temperature rises, the air over India expands, and a larger and larger proportion of the total atmosphere is lifted above the level of the hill stations. In consequence of this, the barometer at first rises at the higher hill stations; and it simultaneously sinks over the plains and the lower hills, owing to the outward movement of the air. As the season advances, more and more air is removed from India by the strong day winds, which blow in the hot weather, as well as by the winds over the Indian watershed that have been already described, while but little is restored by the feeble night winds that come from the opposite quarters; the barometer continues to fall over the plains, and the rise observed at the hill stations in spring, is soon also changed to a fall; except at Leh, where the barometer continues rising until the beginning of May. In the upper half of the atmosphere, that is, above the plane of 15 inches pressure, the summer depression of the barometer, which at Leh is less decided than that of winter, probably disappears altogether, and the barometer stands highest in the hottest season as it would do at all elevations, except the lowest, if there was no transfer of air from place to place by lateral currents or winds.

When the temperature of Northern India is at its maximum, in the latter half of June, the planes of equal pressure are widest apart, and they all slope towards the north in the lower half of the atmosphere. Winds consequently blow in from the sea towards the land in the lower strata, and there are possibly upper currents in the opposite direction; though the existence of such has not yet been established. This relation continues until the autumnal equinox; after which the temperature falls rapidly, and the atmosphere contracts and sinks so as to reproduce the conditions characteristic of the cold weather. The cooling of the air at this season, like the heating of it in spring, produces a differential effect on the height of the barometer at the hill stations, which, again, have a maximum of pressure in October or November.

When the effects of the two actions above described—the expansion and contraction of the atmosphere vertically, and the lateral transference of air by winds—are borne in

mind, some curious and at first sight inexplicable peculiarities of the annual variation of pressure become intelligible. For example, on the plains the barometer almost invariably stands higher in December than in January, though January is the colder month of the two. This anomaly at once disappears when we remember that the total pressure of the air on the plains, considered statically, is made up of two parts—that of the air from the plains up to the hill stations, and that of the air lying above the hill stations. The latter part appears from the observations of Leh to be greatest in the last fortnights of April and October, and least in the beginning of February and the end of July; and if the monthly means for any station on the plains or lower hills be subjected to harmonic analysis, the annual variation will be found to be very closely represented by two harmonic waves—one of annual period, reaching its maximum at the time of greatest cold in the beginning of January, and the other of six months' duration, nearly coinciding in phase with the pressure variation at Leh. The amplitude of the first of these undulations, which is as much as six-tenths of an inch at some places on the plains, rapidly diminishes as we ascend, and passing through a zero value, at about 10,000 feet elevation, re-appears at Leh in nearly the opposite phase, the minimum falling in winter. The amplitude of the half-yearly oscillation increases slightly as we ascend; but it appears to vary with distance from the plains in a horizontal direction as much as with height. The observed pressure on the plains, being due to the superposition of the two waves, is highest in December—that is, between the dates when each wave separately attains its maximum.

The truth of this theory of the annual change of pressure may be more clearly seen from Table IX, where the monthly variations of the barometric weights of three successive strata of the lower atmosphere from their annual mean values are compared with the simultaneous variations of temperature. The last double column gives the variations for the whole thickness of the atmosphere from the plains up to 11,500 feet above sea-level.

IX.—Annual variation of pressure and temperature in the lower atmospheric strata over the Himálaya.

Month.	Roorkee to Dehra, 1,345 feet.		Dehra to Chakráta, 4,820 feet.		Chakráta to Leh, 4,451 feet.		Roorkee to Leh, 10,616 feet.	
	Temperature variation.	Pressure variation.	Temperature variation.	Pressure variation.	Temperature variation.	Pressure variation.	Temperature variation.[1]	Pressure variation.
	°	"	°	"	°	"	°	"
January .	−17·0	+·066	−15 0	+·127	−18·5	+·077	−18·4	+·270
February ...	−13·0	+·018	−12·9	+·122	−16·4	+·080	−15·6	+·251
March ...	− 4·3	+·012	− 4·8	+·041	− 7·1	+·007	− 6·1	+·060
April ...	+ 6·3	−·018	+ 4·7	−.033	+ 2·3	−·024	+ 8 9	−·064
May ...	+12·2	−·010	+ 9 7	−·077	+ 8 0	−·050	+ 9·7	−·167
June ...	+15·2	−·053	+13 0	−·134	+13·6	−·074	+14·4	−·258
July ...	+ 9 8	−·010	+ 8 7	−·104	+14·1	−·051	+13·0	−·105
August ..	+ 8·8	−·030	+ 8·2	−·095	+13·3	−·041	+12·0	−·165
September ...	+ 7·2	−·020	+ 6·6	−·071	+ 9 3	−·028	+ 8·7	−·119
October ...	+ 0·2	−·001	+ 0 6	−·001	+ 0·9	+·009	− 0·8	+·006
November ...	− 9 1	+·028	− 6·3	+·092	− 6 9	+·039	− 7 0	+·160
December ...	−16 0	+·048	−12·4	+·136	−13·1	+·011	−10·5	+·225

It is evident from the table that the barometric weight of each stratum, and of the whole thickness of air between the plains and Leh, varies inversely with the tem-

[1] From the average of the three stations—Roorkee, Chakráta, and Leh.

perature, and that the variations of these two elements are very nearly proportional to each other.

That the peculiar double oscillation of pressure, observed at the hill stations, is due to exactly the same causes as the single oscillation on the plains, may perhaps be better seen, by reducing the mean monthly pressure of Roorkee to the elevation of each of the hill stations in succession. In Table X this has been done according to the formula $log\ p. = log\ P - \dfrac{h(R+H)^2(1-\frac{3f}{8\beta})}{60{,}360\ R^2\ (1+\cdot0028\ cos\ 2\ \lambda),\ \ \{1+\ \alpha\,(t-32)\}}$. The mean height H, adopted in the factor for correcting the acceleration of gravity, is 8,000 feet, and the mean latitude λ has been taken to be 32°. The reduction to the higher levels in Table X has been carried out in successive stages,—Roorkee to Dehra, Dehra to Chakráta, Chakráta to Leh—and in each of these stages the mean temperature, pressure, and vapour tension of the air (t, β. and f) have been taken to be the arithmetical means of the observations at the top and bottom.

X.—*Comparison of computed with observed pressures at the Hill Stations.*

Month.	Dehra.			Chakrata.			Leh.			15,000 feet.
	Computed from Roorkee.	Observed.	Difference.	Computed from Roorkee.	Observed.	Difference.	Computed from Roorkee.	Observed.	Difference.	Computed from Roorkee.
	"	"	"	"	"	"	"	"	"	"
January	27·730	27·731	—·001	23·226	23·259	—·033	19·591	19·630	—·036	14·680
February	·679	·687	—·008	·202	·220	—·018	·586	·587	—·001	·761
March	·618	·629	—·011	·216	·243	—·027	·668	·684	—·016	·996
April	·540	·550	—·010	·225	·238	—·013	·733	·699	+·034	15·166
May	·451	·462	—·011	·201	·194	+·007	·742	·692	+·050	·237
June	·336	·344	—·008	·127	·133	—·006	·727	·652	+·075	·251
July	·350	·349	+·001	·115	·108	+·007	·726	·607	+·119	·301
August	·402	·404	—·002	·156	·154	+·002	·756	·642	+·114	·310
September	·498	·498	+·000	·212	·224	—·012	·774	·700	+·074	·316
October	·630	·641	—·011	·275	·298	—·023	·769	·737	+·032	·208
November	·724	·744	—·020	·293	·307	—·014	·733	·715	+·018	·024
December	·751	·764	—·013	·261	·283	—·021	·661	·690	—·029	14·854
Year ...	27·559	·567	—·008	23·209	·222	—·013	19·706	·670	+·036	15·093

The differences in the table to some extent no doubt represent real baric gradients; but they must also be partly due to unknown errors in the assigned elevations of the stations, differences in the period of observation at the several stations, differences in the

methods of finding the daily mean, and inaccuracies in the assumptions underlying the barometric formula.[1] It is noteworthy that at all the stations the differences have opposite signs in the cold weather and the rainy season respectively, the pressures computed from the Roorkee observations having the cold weather minimum more and that of the hot weather less distinctly marked than those directly observed at the hill stations.

In the last column of the table, the pressure has been reduced to 18,500 feet above sea-level, the monthly mean temperatures of the stratum of air lying between Leh and this elevation being supposed equal to the temperatures given in Table VI opposite 15,000 feet. The pressures, thus calculated, are lowest in the middle of the cold weather and highest in the rainy season, very nearly as they ought to be according to the theory developed in the preceding pages. There is, however, an excess of pressure in the latter half of the year, comparable to that observed at Leh, where the autumn maximum is slightly higher than that of spring; which is not easily accounted for. It may be merely the result of an error in the assumed rate of decrease of temperature; and, on the whole, we may fairly conclude from the table, that in the upper half of the atmosphere over the Himálaya, the pressure is highest in summer and lowest in winter. An important step towards the solution of this and many other problems of meteorology would be the establishment of an observatory for one or two years at some point in Rúpshu, over 16,000 feet above the sea, and yet easily accessible from a permanently inhabited village.

The annual variation of the wind in Northern India is, for the most part, such as should accompany the pressure variations above described, according to the usually received "convection current" theory; but there is one important feature of the winds of the plain, that has not yet been satisfactorily explained—namely, the prevalence during the hot weather of strong north-westerly winds when the distribution of temperature and pressure are frequently such as should, by the theory of convection currents, give rise to winds with a southerly element. These "winds of elastic expansion," as they have been called by Mr. Blanford, actually blow sometimes from places where the mean pressure is low to others where it is slightly higher[2]. They are the strongest winds of the year on the Indian plain; they blow only in the daytime; and since there is no compensating current of any appreciable strength at night, they are probably the chief agency in that removal of air from Upper India which causes the great summer depression of the barometer. They are not confined to India, but are equally characteristic of Afghanistan; and Colonel Prejevalsky encountered winds, perfectly similar in everything except temperature, in various parts of the Gobi desert and on the Alashán plateau north-east of Tibet. On the southern slope of the Himálaya, these winds are sometimes met with up to elevations of 6,000 or 7,000 feet, and when they blow the air is unusually dry and full of dust. At greater elevations, however, they are either not felt, or become undistinguishable from the ordinary up currents that blow during the day.

[1] When all these sources of error are as far as possible corrected, there is still a residue which points apparently to a curious accumulation of air over the outer ranges of the Himalayas, first noticed, I believe, by Mr. J. Eliot. When the mean pressure of any Himalayan station, except Leh, is reduced to sea-level, the result is always higher than that given by a neighbouring station on the plains, and this result is independent of the season or the direction of the wind.

[2] It does not follow, of course, that the wind blows in opposition to the well-known laws of hydro-dynamics. These winds blow chiefly in the afternoons when the pressure is falling rapidly, and when, therefore, the pressure is higher on the western than on the eastern side of India, though the mean pressure may be uniformly distributed. The velocity of the wind has apparently but little relation to the pressure gradient, which is always very small.

XI.—Mean resultant wind directions at places in the Himálaya.

Place.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Number of years.
Bareilly ...	N.57°W.	N.51°W.	N.66°W.	N.46°W.	N.52°W.	N.85°E.	S.64°E.	S.27°E.	N.86°E.	N.25°W.	N.5°W.	N.76°W.	9—12
Roorkee ...	N.71°W.	N.51°W.	N.76°W.	N.76°W.	S.21°W.	S. 9 E.	S.37°E.	S.21°E.	S.22°E.	S.27°E.	S.6°W.	N.84°W.	10—12
Dehra ...	S.68°W.	S.67°W.	S.70°W.	S.71°W.	S.63°W.	S.63°W.	S.67°W.	S.60°W.	N.61°W.	N.61°W.	N.25°W.	S.[illegible]W.	9—13
Dharmsála ...	S.71°W.	S.73°W.	S.50°W.	S.69°W.	S.49°W.	S.65°W.	S.71°W.	S.71°W.	S.27°W.	S.66°W.	S.22°W.	S.45°W.	4—5
Ránikhet ...	S.81°W.	S.54°W.	S.57°W.	S.63°W.	S.63°W.	S.75°W.	S.60°W.	S.61°W.	S.45°W.	S.22°W.	S.21°W.	S.45°W.	7—10
Naini Tál ...	S.19°E.	S.29°E.	S. -	S.57°E.	S.19°E.	S.46°E.	S.41°E.	S.41°E.	S.41°E.	S.41°E.	S.25°E.	S.41°E.	7
Chakráta ...	S.63°W.	S.10°E.	S.	S.59°W.	S.55°W.	S.74°W.	S.63°W.	S.67°W.	S.69°W.	S.66°W.	S.45°W.	S.45°W.	6—10
Leh ...	S.21°W.	S.21°W.	S.37°W.	S.29°W.	S.41°W.	S.51°W.	S.62°W.	S.51°W.	S.56°W.	S.35°W.	S.20°W.	S.15°W.	5

From the preceding table it is seen that, though the change of the prevailing wind from north-west to east or south-east, at the commencement of the rains, is very distinctly marked on the plains, no such change takes place at the hill stations. Even at the lowest of these, Dehra, the resultant wind varies only from about three points north to the same distance south of west. At all the higher stations, the prevailing direction in every month is southerly or south-westerly, with modifications depending on the form of the ground,—at Naini Tál, for instance, the winds are generally south-easterly. The only notable variation of the wind direction is a deflection towards the east at Chakráta (also at Simla, Marri, and other stations on the north-western Himálaya) at the time when the winter snows and rains are heaviest. The cause of this has not yet been ascertained; but it is probably an indication of a cyclonic movement of the air in the Panjáb, extending to a height exceeding 7,000 feet.

The wind direction at the hill stations changes so little from month to month, because the winter monsoon is of no great vertical thickness, while that of the summer months extends to a much greater elevation than the highest station at which observations have been made. When northerly or north-westerly winds are blowing on the plains, the return current from the south-west is felt on the mountains at all elevations above the first few thousand feet; and when southerly winds blow over the plains, the return current, if it exists at all, lies at a very great altitude. The existence of this return current from the north, during the summer monsoon, may possibly be proved by cloud observations. Dr. Scully's observations on the way back from Yarkand in August, 1875, tell neither for nor against it, the resultant of all the wind directions observed at elevations above 14,000 feet being due west.

In the next table, the vertical thickness of each monsoon current on the Himálayan slope has been computed, approximately, from observations made at pairs of hill stations in the north and south of India. The northern stations are Roorkee and Chakráta, and the southern ones, Colombo and Newera Eliya in Ceylon. To render the figures directly comparable, the observed pressure at the hill stations have been reduced to the common elevation of 7,000 feet, and those of the lower stations to sea-level, as was done by Mr. Blanford in drawing up a similar table in the *Indian Meteorologist's Vade Mecum*, page 175.

XII.—Vertical thickness of the monsoon currents.

Season.	Month.	Mean pressure at 7,000 feet.			Mean pressure at sea-level.			Neutral plane.	
		Ceylon.	Dehra Dún.	Gradient sending wind towards north.	Ceylon.	Dehra Dún.	Gradient sending wind towards north.	Approximate pressure.	Approximate elevation in feet.
		"	"	"	"	"	"	"	
Winter.	November	23·383	23·356	+·037	29·901	30 025	−·124	24·80	5,390
	December	23 360	23 338	+·012	29·908	30 074	—·166	24 73	5,370
	January	23·380	23·305	+·075	29·918	30 070	−·152	25·54	4,480
	February	23·392	23·269	+·123	29 922	29·994	—·072	27 56	2,390
Summer.	June	23·347	23 178	+·169	29 857	29 483	+·374	17·98	14,000
	July	23 341	23·159	+·182	29·870	29 503	+·367	16 92	15,730
	August	23·342	23 204	+·138	29 877	29 577	+·308	17·78	14,310
	September	23 356	23·273	+·083	29 895	29 685	+·210	19 08	12,420

At 7,000 feet elevation, the pressure gradient in both seasons is such as to send a current from south to north; while, at sea-level, it is only in the winter season that the wind blows from north to south. The neutral plane separating the lower wind current from the supposed upper return current is nearly 16,000 feet above the sea in the height of the rainy season; but in the cold weather, especially in January and February, the neutral plane is below the level of the hill sanitaria.

The heights in the table represent only the approximate mean positions of the neutral plane for the several months. In reality, its height is constantly fluctuating, and thus in the winter season it often sinks so low as to strike the Indian plain below the base of the hills. A moist easterly or south-easterly current then blows for several days at a time in Upper India, bringing the winter rains, while in Southern India the wind may be northerly.[1] The *prevailing* direction of the wind on the plains is, however, always northerly in the cold weather, in accordance with the mean position of the neutral plane.

The pressure gradients both at sea-level and at 7,000 feet are much greater in summer than in winter. In the latter half of October and the beginning of November, there is hardly any gradient either way; and, at that time, feeble winds and calms prevail. The velocity of the wind being directly proportional to the baric gradient, (except perhaps in the case of anomalous currents like the "winds of elastic expansion" which blow down the valley of the Ganges in the hot weather), this velocity should be greater in the rainy season than in winter.

XIII.—Monthly mean velocity of wind in miles per diem.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Roorkee	55 8	65 9	67·3	74·6	91·9	101·0	78·3	64·3	55·0	36·9	31·8	33·4	63·0
Bareilly	70 6	95·4	95·1	110·4	117·2	134·5	105·5	97·0	83 7	53 2	48·3	59·1	89 2
Dehra	40 1	49 2	57 6	69 6	64 7	54·0	31 9	29·6	37·3	43 7	59·8	47 3	49 6
Ránikhet	71·9	77·0	87·1	131·3	98 0	120 0	129 1	137 7	101·9	87·6	60·6	64·5	98 9
Chakráta	114·5	114 6	129·4	137 0	135·8	128·1	110·1	95 9	108·4	125·7	106·1	102·1	116·7
Leh	17·7	30 9	43·4	73·9	71·2	54·0	38·3	22·8	20 4	30 0	41·7	20 7	38 8

[1] Mr. F. Chambers (*Nature*, Vol. 23, page 400) attributes the winter rains to cyclones entering the Panjáb from the west. It seems highly improbable that a cyclonic distubance could cross the Hindu Kush or the Sulaiman range; but supposing it were to do so, the winds in its southern and eastern border must be fed by descending curents in the region of high pressure separating the cyclonic area from the region of low pressure near the equator; and the winter rains would thus still be due to the vapour brought by the upper current.

Table XIII shows that on the plains and at Ránikhet and Leh, (for which stations more observations are required to get a good average) the wind velocity is least in winter; but that, at Chakráta and Dehra, it is least in the rains. At these stations on the outer border of the mountains, the winds are chiefly of the diurnal kind, and are weakest when the temperature range is least—that is, in the month of August.

HUMIDITY AND CLOUD.

The quantity of water vapour, present in the air at any time, is a most important meteorological condition. It depends on the temperature, the distance from the sea or other evaporating surface, and the direction of the wind. These relations are very distinctly marked on the North Indian plain, where the high temperature range in the yearly period and the semi-annual change of the winds combine, to render the proportion of vapour in the air, during July and August, nearly three times as great as in December and January. A high temperature cannot, of course, increase the quantity of vapour in the air, unless it be in a region where vapour is being generated. Accordingly we find in Table XIV, that the vapour pressure at Roorkee, on the drier part of the plain, hardly varies from December to April; though, as soon as the sea winds set in, which they sometimes do in the middle of May, the proportion of vapour rapidly increases. At Bareilly, where the surrounding country is moister and better wooded than at Roorkee, there is a slight increase of vapour in the hot-weather months.

XIV.—Monthly mean tension of aqueous vapour at places in the Himálaya.[1]

Place.	Elevation in feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Number of years.
		"	"	"	"	"	"	"	"	"	"	"	"	"	
Bareilly	568	·308	·335	·405	·442	·560	·740	·922	·907	·838	·585	·392	·321	·563	12
Roorkee	887	·290	·317	·356	362	·462	·656	·875	·872	·787	·621	·345	·298	·512	13
Dehra	2,232	·294	·325	·372	·418	·511	·721	·881	·878	·794	·521	·356	·301	·531	12-13
Dharmsala	4,495	·271	·281	·352	·430	·459	·539	·643	·627	·601	·444	·294	·271	·436	4-5
Mussooree	5,830	·169	·203	·215	·294	·319	·437	·600	·594	·576	·370	·238	·230	·358	1-3
Ránikhet	6,069	·180	·192	·231	·263	·335	·457	·579	·572	·515	·339	·216	·191	·312	7
Chakrata	7,032	·155	·165	·198	·233	·298	·415	·542	·531	·477	·301	·194	·161	·306	10-11
Kumaun and Garhwál[2], ...	8,000 to 9,000	...	·140	·220	...	...	·100	...	...	..	·280	...	...	?	...
Ditto	9,000 to 10,000	...	..	...	...	...	·420	...	...	..	·250	...	...	?	...
Ditto	10,000 to 11,000	...	...	...	...	...	·310	·350	...	...	·330	...	...	?	...
Leh	11,538	·103	120	·134	·142	·167	·217	·339	·313	·216	·144	·115	·093	·177	4
Kumaun and Garhwál[2], ...	12,000 to 13,000	...	...	...	...	...	·210	·250	·320	..	...	...	...	?	...
Ditto	13,000 to 14,000	...	...	...	...	...	...	·200		...	...	...	...	?	...
Ditto	14,000 to 15,000	..	...	...	...	...	...	·140	·210	·200	·120	..	...	?	...
Ditto	15,000 to 16,000	...	...	...	...	...	...	·140	·130	·110	...	...	...	?	...
Ditto	16,000 to 17,000	...	...	...	...	...	...	·120	·180	...	...	..	...	?	..
Ditto	17,000 to 18,000	...	...	...	...	...	...	·130	...	...	...	...	...	?	...
Ditto	18,000 to 19,000	...	...	...	...	...	...	·120	·150	...	...	...	...	?	...

[1] There is a certain diurnal variation of vapour tension, but its range is very small and it varies a good deal at different places. For most of the stations in the table, the correction for this variation is unknown, and the figures in the table are simply the crude means of all the observations. For Bareilly, Roorkee, Mussooree, Ránikhet, and Chakráta they are derived from three or four observations daily, and for the other stations from two observations. The figures for Dehra are probably too high.

[2] From miscellaneous observations by General Strachey.

On the southern slope of the mountains, the annual variation of vapour tension is similar to that which obtains on the plains; though, because of the considerable evaporation from the forest-covered slopes, and the occasional showers of rain which fall, the increase of vapour during the hot weather goes on much more uniformly than on the plains. At Leh, where hardly any precipitation occurs at any time of the year, but in the neighbourhood of which place there is some cultivated land irrigated from the hill streams, the annual variation of vapour tension is determined almost entirely by the temperature. In the valley of Yárkand, the quantity of vapour in the air is similarly determined by the temperature and the extent of irrigation.

In the mountains, the mean vapour tension decreases very rapidly with the height, on account of the rapid decrease of temperature as we ascend. If Dalton's law, that in a mixture of gases or vapours, the pressure of each is the same as if it filled the whole space alone, were applicable to the atmosphere, as is sometimes supposed even yet, then the pressure or tension of vapour observed on the plains ought to be reduced one-half, on ascending through 29,000 feet; but it is found by observation, that a vapour pressure, equal to half that observed on the plains, is attained at an elevation of 7,000 or 8,000 feet. This was pointed out by General Strachey in the *Proceedings of the Royal Society* for March, 1861, where he has shown that the observations of Mr. Welsh in balloon ascents, those of Dr. Hooker in Sikhim, and his own observations in Kumáun, (most of which are included in Table XIV), make it perfectly certain that the proportion of water vapour which exists at any given elevation is determined, not by Dalton's law, but simply by the temperature. The vapour raised from the earth's surface is constantly diffusing upwards, and would go on doing so until it attained the state of equilibrium represented by Dalton's law; but the temperature falls so rapidly as the height increases, that saturation point is reached and the vapour is partially condensed into cloud or rain, long before the barometric equilibrium is attained.

In the third column of Table XV, the figures given in the previous table have been compared in a manner suggested by Strachey. The tension of vapour at sea-level under Kumáun and Garhwál has been computed for each month, by multiplying the mean of the observed tensions at Roorkee and Bareilly into the ratio between the tension of saturated vapour at the sea-level temperature and that of saturated vapour at the temperature of the plain; that is to say, the temperature is supposed to be corrected for elevation above the sea, while the degree of saturation remains constant. The figures in Table XIV have then been divided by the corresponding tensions at sea-level; and the average of the fractions, for all the months, has been calculated for each elevation. Finally, from these results, the ratio of the tensions, at each even thousand feet above the sea, has been found by interpolation. The second column of the table gives the results of Sir Joseph Hooker's observations in Sikhim compared with those afterwards taken at the meteorological observatory of Goálpara near the foot of the hills, and the fourth column has been computed from the observations in General Cunningham's *Ladák* and those taken by Dr. Scully on the way back from Yárkand in 1875. The latter have been published in the present volume of these Memoirs, pages 233 to 216. The base station for the Kashmir group is Ráwal Pindi. The figures opposite 7,000 feet, in the second and fourth columns, are derived from the monthly means of the Darjiling and Marri observatories.

XV.—Ratios of vapour tension at various elevations in the Himálaya.

Height.	Sikhim.	Kumáun.	Kashmir and Ladákh.	Mean of all three		
				Observed.	Calculated by Strachey's method.	Calculated by Hann's method.
Sea-level	1·00	1·00	1·00	1·00	1·00	1·00
1,000 feet	·89	·92	·92	·91	·91	·91
2,000 „	·83	·91	·85	·86	·83	·82
3,000 „	·74	·86	·69	·76	·75	·74
4,000 „	·67	·78	·52	·66	·68	·67
5,000 „	·64	·71	·51	·62	·62	·61
6,000 „	·59	·60	·57	·59	·56	·55
7,000 „	·53	·53	·60	·55	·51	·50
8,000 „	·50	·50	·41	·47	·46	·45
9,000 „	·44	·48	·28	·40	·42	·41
10,000 „	·40	·46	·27	·34	·38	·37
11,000 „	·37	·37	·26	·33	·34	·33
12,000 „	·35	·30	·21	·29	·31	·30
13,000 „	·30	·25	·23	·26	·28	·27
14,000 „	·27	·21	·19	·22	·25	·24
15,000 „	·27	·17	·15	·20	·22	·22
16,000 „	·22	·15	·16	·18	·20	·20
17,000 „	·20	·15	·14	·16	·18	·18
18,000 „	·19	·14	·15	·16	·16	·16
19,000 „	·18	·13	·14	·15	·14	·15

The mean of all three sets of observations probably represents very closely the actual diminution of vapour pressure on ascending in the Himálaya. It decreases with more regularity than either the Kumáun or Kashmir series of observations alone, and it agrees very closely with the series for Sikhim, where the relative humidity, or percentage of saturation, varies much less than in the western Himálaya. The last column of the table but one, gives a series of ratios, calculated on the assumption that the degree of humidity is the same at all elevations, and that the temperature of the southern slope of the Himálaya decreases at the mean rate above found—one degree in 301 feet. This series agrees very closely with the average of the results given by observation; though from 2,000 to 11,000 feet the calculated ratios are all considerably less than those observed in Kumáun. During the hot-weather months, the degree of saturation on the plains below Kumáun falls exceedingly low; while, on the hills, as has already been stated, the air remains much moister; at Dehra, for example, the vapour pressure in March, April, May, and June is greater than at Roorkee, owing to local evaporation. Thus, on the average of the year, the relative humidity of the air in the Kumáun hills is considerably greater than over the plain. On the other hand, the observed ratios from 14,000 feet upwards are less than those given by calculation, because most of the observations at these altitudes were made at places lying behind the snowy range.

In the last column are given the ratios calculated by the logarithmic formula, $\log p = \log P - h \div 23058$, where h is expressed in feet. Dr. Julius Hann, in an article in the Austrian Meteorological Society's Journal for 1874, page 193, has deduced from all the available observations on mountains and in balloons, a similar formula, in which the numerical constant is 6,517 metres, or 21,380 feet. On the assumption that the above formula holds good to some distance beyond the limits of observation, we find that, at an elevation of 23,000 feet, or about the average height of the snowy peaks, the quantity of vapour in the air is only one-tenth of the quantity at sea-level. The extreme dryness of Tibet and Ladákh is thus easily accounted for.

The logarithmic formula has the advantage of enabling us to calculate approximately the total quantity of vapour in the air at any time, by an application of the integral calculus. Using the generally received values for the density of water vapour and its co-efficient of expansion by heat, and extending the integration to an infinite height above the ground, it is found that the depth of water that would be formed by the complete condensation of the vapour over a given area, is almost exactly three times the height of the mercurial column which measures the pressure of the vapour at the bottom. In the rainy season, for example, when the pressure of vapour over the Indian plain is equal to about an inch of mercury, the complete precipitation of the vapour would yield only three inches of rain, that is, less than the quantity which sometimes falls in two or three hours. A continuous downpour, amounting to fifteen or twenty inches, such as frequently occurs in India, must be fed by a powerful indraught of moist air.

The relative humidity of the air is probably greater at all elevations on the Himálayan slope, than either on the plains or on the Tibetan plateau beyond the Indian watershed; and it is doubtless greater on forest-clad slopes and valleys, than on steep and bare mountain sides. On a high ridge, too, which intercepts and deflects upwards the prevailing south-west winds, thereby cooling them and partially condensing their vapour, the degree of saturation is greater than on the lower ridges or valleys behind it; for the air, in sinking after crossing the high ridge, is warmed and rendered capable of absorbing more moisture than it has been able to retain in crossing the ridge. Thus Naini Tál, independently of the influence of the lake, is always much moister than Ránikhet or the notoriously dry and bare station of Almora. The registers of the meteorological observatories do not, however, illustrate this very well; for, at several of them, observations have only been taken in the daytime, when the relative humidity is below the mean; and the humidities recorded at the old observatory of Naini Tál are quite untrustworthy, and in many cases impossible. At Bareilly, Roorkee, Ránikhet, and Chakráta observations were taken both night and day for some years, at the hours of ten and four. If the means of the four observations at these hours be adopted as daily means, Chakráta appears to be the most humid of the four stations, and Roorkee and Ránikhet the driest, though the difference between Chakráta and Roorkee or Ránikhet is less than might be anticipated. The humidities of the other places in Table XVI, have been calculated approximately from the monthly means of temperature and vapour tension. The figures for Leh in the winter months are doubtful; the psychrometer generally giving unreliable results, when the temperature falls much below freezing.

XVI.—Approximate mean humidities of places in the Himálaya.

Place.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Bareilly	69	63	51	39	43	59	82	83	81	70	65	69	65
Roorkee	69	65	63	36	37	51	78	80	77	65	62	68	62
Dehra	69	69	58	47	45	63	86	90	86	69	62	67	70
Dharmsála	83	73	67	57	51	55	79	[illegible]	77	69	56	67	68
Mussooree	62	63	52	48	48	58	91	95	93	64	52	70	67
Ránikhet	60	58	52	39	49	61	85	86	79	60	53	54	62
Chakráta	68	64	56	49	57	68	94	94	89	64	49	58	67
Leh	100	100	74	53	49	48	63	61	61	55	63	70	66

The relative humidity of the air, at all elevations up to 11,500 feet, is subject to a double annual variation; one maximum occurring at the time of greatest cold, and the other in the middle of the rainy season. At Leh, the summer maximum is very faintly marked, nine-tenths of the vapour brought by the south-west monsoon being cut off before reaching the station; and at Dharmsála, north of the Panjáb, the air appears to be slightly more humid in winter than in summer. At all the other stations, the maximum degree of humidity is reached in August.

In April and November, the air is dry, especially in the former month, when, during hot winds from the north-west, the percentage of saturation over the plains often falls as low as 5 or 6. In the hills, at Almora and Ránikhet, the humidity of the air frequently sinks to 25 per cent., but is seldom less than 20 per cent. The month of November and the beginning of December appear to be quite as dry as April at the higher hill stations, where these months are rainless; while showers sometimes fall in April; but on the plains, because of the low temperature of November and the moisture left in the ground by the summer rains, the air is still comparatively moist. In the cold weather, the Sub-Himálayan stations are more humid than the hill stations, on the average of the twenty-four hours; probably because the air which is cooled and has its relative humidity increased by radiation during the night, drains away from the hills and collects over the plain. At this season, the air at the hill stations appears to be drier in the mornings than in the evenings.

The humidity of the upper regions of the atmosphere, as indicated by clouds, is always greater in the daytime than at night. On the outer slope of the Himálayan chain the variation is doubtless quite as distinctly seen as anywhere else in the world, but it has not been recorded in the observatory registers, where only the amounts of cloud seen at 10 A.M. and 4 P.M. have been entered. The variation is, however, probably very similar to that which occurs over the plains, where the sky is most serene about 10 P.M.; and most cloudy at the hottest time of the day, when the upward convection currents are strongest. In Table XVII, the figures represent the means of the 10 A.M. and 4 P.M. observations, and they are therefore a little above the true mean for the day.

XVII.—Average proportion of cloudy sky in tenths of the expanse.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Bareilly	2·87	3·12	2·97	1·96	1·46	3·98	7·11	6·18	4·50	0·73	0·72	1·85	3·12
Roorkee	2·96	3·47	3·12	2·25	1·71	2·90	4·97	4·50	4·58	0·99	0·82	2·18	2·87
Dehra	3·73	4·07	3·55	2·50	2·75	4·02	7·50	7·00	4·83	1·08	1·33	2·74	3·76
Dharmsála	4·99	3·91	3·42	2·17	2·60	3·26	7·60	6·76	4·09	0·74	0·95	2·02	3·54
Ránikhet	3·66	4·42	3·78	3·31	3·58	5·41	8·58	8·42	5·64	1·69	1·31	2·99	4·40
Chakráta	4·23	4·75	4·44	3·42	3·75	5·14	8·89	8·57	6·79	2·28	1·74	3·62	4·80
Leh	6·32	6·38	6·27	5·78	5·77	5·50	4·89	4·68	4·44	4·19	5·12	5·91	5·44

The annual variation of cloud is similar to that of the relative humidity of the air near the ground. It has two maxima, in the cold weather and the rainy season, and two minima, in April or May and in November. April is cloudier than November, probably because the upward movement of the air during the day then prevails over the downward movement at night, while in November the prevalent movement is downward. In this way the air in the upper strata is dynamically cooled in the hot-weather months and dynamically heated in November. The variation of humidity at the hill stations is intermediate in character between that observed on the plain and the variation in the cloud-bearing strata of the atmosphere.

No direct observations of the heights of clouds above the ground have been made in the Himálaya. The ordinary clouds of the rainy season, that look like broken cumulus from below, are often not more than 5,000 or 6,000 feet above sea-level, hill stations like Naini Tál and Mussooree being frequently enveloped in them for days. They sometimes even extend down to the level of the plains, the whole mass of the mountains up to the snows being then shrouded in fog. From the vapour tensions given in Table XIII, and the temperature decrements in Table V, it is possible to calculate approximately the average height at which a mass of air rising up from the plain would reach the dew-point and begin to form cloud. In January this height is a little over 5,000 feet above the plain, or about 6,000 feet above sea-level. In April and May the height above the sea is over 8,000 feet, and at this time of the year it is rare to find clouds resting on the outer ridges of the Himálaya, though great banks of them are formed every day along the southern face of the snowy range. In the rainy season, that is, between the middle of June and the end of September, the average height at which clouds would commence to be formed in a rising column of air is 3,200 feet above the plain or about 4,000 feet above sea-level. This probably coincides very nearly with the zone of greatest rainfall on the mountains. In July and August, when the air is most humid and rainfall most frequent, the average lower limit of cloud is probably about 3,400 feet above the sea.[1]

Regarding the upper limit of cloud nothing is known. The light feathery ice-cloud called cirrus, seen above the plains of Tibet and the passes over the Indian watershed, appears quite as high as when viewed from the Indian plain. It is probably formed at

[1] The mean elevation at which an ascending column of air would attain the dew-point in each month is the following :—

January	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
6,088	5,981	7,316	9,057	8,258	6,813	3,420	3,436	3,867	5,650	7,723	7,303

These figures are deduced from the observed tensions of vapour at Roorkee and Bareilly, and the rates of temperature decremen given in Table V.

all elevations to which water vapour extends, though what the upper limit of vapour is we do not know. If we assume the cirrus clouds over the Tibetan plateau to be twice as high as the plateau itself, say 30,000 feet above sea-level, the quantity of vapour in the air would be only one-twentieth of that observed on the plains of India, but it would probably be quite sufficient to form light clouds.

RAIN AND SNOW.

The distribution of rain both on the plains and on the mountains has already been described in a general way. The plains of Northern India, between the mountains and the Jumna river, or a line drawn north-westward from Delhi beyond the river, may be divided into roughly parallel zones of equal rainfall; that which receives the greatest amount of precipitation lying nearest to the Himálaya. The breadth of each of these zones gradually diminishes towards the north-west, and widens out in the direction of Bengal, because, the prevailing wind of the rainy season being easterly over the plain, the supply of vapour gradually diminishes and the rains become lighter as we pass from east to west. In Table XVIII, the average monthly rainfalls of 15 places on the plains, near the base of the hills of Kumáun, Garhwál, and Dehrá Dún, are given. The first group of stations is at an average distance of 20 to 30 miles from the base of the hills, and the distance of the other group is under 20 miles. In both groups the stations are arranged in order from east to west. The table might be extended indefinitely in both these directions as well as southwards, but little would be gained by doing so, since the distribution of rain above described is seen clearly enough from the figures as they stand.

XVIII.—Rainfall of stations on the plains near the base of the Himálaya.

Station.	Elevation in feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Number of years.
		"	"	"	"	"	"	"	"	"	"	"	"	"	"
Nawábganj ...	610	1·28	1·15	0·55	0·27	1·29	5·82	16·89	11·27	7·91	1·42	0·01	0·47	48·39	17
Baheri ...	690	1·12	1·40	0·63	0·28	1·25	5·35	17·05	11·35	6·80	1·09	0·06	0·44	46·82	17
Thákurdwára ...	720	1·55	1·63	0·73	0.56	1·06	5·93	13·55	11·01	6·75	0·75	0·08	0·64	41·29	17
Bijnor ...	800	1·14	1·22	0·86	0·54	0·70	4·82	10·51	9·01	6·06	0·51	0·05	0·41	35·86	31—33
Deoband ...	870	1·16	1·31	0·99	0·38	0·78	2·46	10·15	7·75	4·78	0·36	0·03	0·61	30·76	17
Saháranpur ...	950	1·42	1·51	1·09	0·42	0·82	4·46	12·12	9·51	3·88	0·49	0·17	0·61	36·80	31—33
Ambála ...	820	1·41	1·38	1·01	0·63	1·03	4·18	11·53	8·75	4·57	0·81	0·14	0·71	36·18	25—26
Puranpur ...	620	1·32	1·90	0·53	0·50	0·62	5·40	20·40	13·91	8·86	1·93	0·01	0·81	56·25	6—7
Pilibhit ...	650	0·99	1·41	0·45	0·37	1·15	6·25	16·19	11·52	9·99	1·23	0·01	0·46	50·22	17
Rudarpur ...	720	1·18	1·42	0·80	0·32	1·16	5·74	14·79	10·81	5·57	0·97	0·07	0·46	43·59	21
Káshipur ...	750	1·47	1·53	0·79	0·49	1·42	6·05	13·29	11·09	5·79	0·78	0·10	0·63	43·48	17
Dhámpur ...	780	0·96	1·84	0·74	0·58	0·95	4·22	13·11	11·31	7·34	0·47	0·03	0·64	42·19	17
Nagina ..	850	1·18	1·79	0·81	0·54	0·95	5·03	13·97	12·34	5·32	0·51	0·01	0·69	46·14	17
Najíbabad ...	870	1·49	1·92	0·92	0·78	1·02	5·64	15·20	13·36	9·11	0·82	0·03	0·69	50·98	17
Roorkee ...	890	1·95	1·63	0·90	0·36	1·04	5·34	12·06	12·12	4·50	0·70	0·22	0·49	41·22	27

·The average rainfall of the line of stations at a distance exceeding twenty miles from the Himálaya, is 40·1 inches, and that of the stations at a distance less than twenty miles is 46·6 inches. In each group, the total rainfall gradually diminishes in passing from the extreme east of Rohilkhand to the neighbourhood of the Ganges, where it increases suddenly and again gradually shades off to the westward. The mean wind directions for the rainy season at Roorkee, Meerut, and Delhi indicate that there is frequently a sort of eddy formed, at that season, near the upper course of the Ganges, probably by the meeting of the south-east winds of the plain with south-west winds from the Arabian Sea, that have been deflected northward by the Aravali hills in Rájputána; and this may be the cause of the increased rainfall that is observed.

On the mountains, the rainfall varies rapidly with height; and its quantity is, to a very great extent, dependent on the situation of the place to the windward or leeward of high ridges and peaks. At fairly exposed stations of nearly equal altitudes, there is a gradual diminution of the annual rainfall, on passing from west to east, comparable to that which occurs on the plain. Thus the annual rainfall of Darjíling is 120 inches, that of Naini Tál varies from 92 to 110 inches in different places, that of Mussooree is 92 inches, and that of Chakráta, Simla, and Marri 62, 68, and 58 inches respectively.

The next table gives the average monthly and annual rainfall of twenty-two places on the Himálayan slope, classified into three groups according to their positions near the foot of the slope, on the outer high ranges or on the inner ranges and valleys.

XIX.—Rainfall on the Himálaya.

	Station.	Elevation (in feet).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Number of years.
			"	"	"	"	"	"	"	"	"	"	"	"	"	
Bhábar, Siwáliks, and Dehra Dún.	Kilpuri	800	1·32	1·72	0 84	0 56	1·35	8·08	19 80	14·98	9·42	1·38	0·06	0·51	59 52	17
	Haldwáni	1,430	1·40	3·18	1·78	0·79	1·32	10·61	21·34	20 07	10·92	1·36	0·06	0·62	73·45	17
	Hardwár	1,100	2·98	2·80	1·03	0·08	0·45	4·38	10·79	14·54	9·94	0 86	0·05	0·32	48·22	6
	Mohan	1,330	3 65	2·91	1·82	0·83	0·79	9·23	19·86	17·48	5·70	1·72	0·58	0·50	65·07	4
	Bhogpur	2,450	1·47	3·27	1·23	1·27	4·87	8·63	57·99	57·77	19·58	0·53	0·27	0 70	157 57	3
	Dehra (Tahsil) ...	2,230	2·06	2·10	1·41	0 73	1·39	8·32	24·71	23·33	9·22	0·72	0·09	0·58	74·66	31-33
	Do. observatory ...	2,232	1·71	2·90	2·04	0·91	1·89	8·54	27·85	23·53	12·15	0 81	0·13	0 81	83·27	13
	Ambári	1,800	1·67	2·38	0·85	1·13	2·67	11·65	24·25	23·72	10·27	0·28	0·57	1·10	80 54	3
	Kalsi	2,000	2·21	3·42	2 22	0·96	1·54	8·02	25·10	26 01	10·14	0·84	0·04	1·01	81·51	17
Outer ranges.	Naini Tál (Tahsil) ...	6,600	3·04	3·34	2·34	1·78	2 97	15·42	25·04	23·54	11·01	1·74	0·19	1·61	92·02	30-31
	Do. Convalescent Depôt.	6,300	2·28	3 80	1·35	2 39	4·43	18·27	33·40	22·26	17·42	1·58	0·55	3·15	110 88	3-4
	Mussooree (St. Fidelis's School).	5,830	2·48	3 67	1·47	3·27	4·28	13 99	37·16	54·30	19·20	0·20	...	2·23[1]	142 25	1-3
	Mussooree (Hospital) ...	6,550	1·92	3 08	3·47	1·77	3·22	8·43	28·48	29·31	10·39	0·77	0·18	1·06	92 08	16-28
	Chakráta	7,052	1·41	2·63	3·41	1·88	3·13	7·97	17·78	15·52	6·26	0·56	0·27	1·24	62 66	12
	Landaur	7,511	2·47	1·44	1·68	2·49	4·60	7·24	26·41	30 86	7·69	0·62	0 68	0 95	87·13	5
Inner ranges and Valleys.	Champáwat	5,550	2·12	3·59	2 23	1·49	3 54	7·46	15 01	11·16	6·65	2·02	0·15	0·99	57·41	17
	Pithorágarh ..	5,500	1·72	2·83	1·84	1·72	3·28	7·68	13·08	9 60	5·17	1·29	0·06	0·85	49·12	17
	Almora	5,400	2·11	2 08	1·54	1·09	2·16	5 90	9·78	7 91	4·89	0·91	0·21	0·66	39·24	35-37
	Ránikhet	6,069	1·63	2·62	1·60	1·62	3·11	5·83	13·50	11·49	6·88	0·71	0·22	1·20	49·41	10
	Pauri	5,350	2 61	2 98	2 29	1·29	2 63	5·42	13·65	12·41	5·44	0·62	0·25	0·79	50 38	30-31
	Srinagar	1,750	2 20	3 44	2·38	1·05	2·25	4·35	8·76	7·69	3·55	0·62	0·11	0·83	37·23	16-17
	Leh	11,538	0 10	0·01	0·01	...	0·05	0·03	0·22	0·71	0·21	...	...	...	1·32	3

[1] Interpolated from upper station in same years.

The influence of an elevated ridge, in diminishing the rainfall of the valley behind it, is seen on comparing the rainfall of Almora with that of Naini Tál, or even by comparing Srinagar with Pauri, though both of these lie far in the interior of the mountain system. A much greater contrast is observable between Bhogpur, at the foot of the mountains overhanging the gorge of the Ganges above Hardwár, and Dehra, in the Dun, behind the central and highest part of the Siwálik chain. The rainfall of Bhogpur, given by the observations of three years, is, however, probably too high.

The variation of rainfall with height can only be roughly determined, because every high ridge and peak thus cuts off the supply of vapour from the lower ground to the north of it. In Table XX, an attempt has been made to determine it approximately from the rainfall figures in the first two sections of Table XIX, together with those of two or three places in the hills north of the Panjáb, and the observations made by General Strachey at Níti in 1849. The ratio between the mean rainfall of each hill station and that of the nearest station or stations on the plains, for the same years, is given in the last column.

XX.—Rainfall of the outer slope of the Himálaya compared to that of the neighbouring plain.

Hills.			Plains.				
Station.	Height in feet.	Rainfall.	Nearest station or stations.	Height in feet.	Rainfall.	Difference of elevation.	Rainfall ratio.
		"			"		"
Kilpuri	800	59·5	Rudarpur	720	45·7	80	1·30
Hardwár	1,100	48·2	Roorkee	890	43·9	210	1·10
Patháнkot	1,160	50·2	Gurdáspur	900	30·1	260	1·67
Mohan	1,330	65·1	Roorkee	890	39·8	440	1·64
Haldwáni	1,430	73·5	Rudarpur	720	45·7	710	1·61
Ambári	1,800	80·5	Sahâranpur and Ambála ...	890	34·6	910	2·33
Kálsi	2,000	81·5	Ditto	890	36·8	1,110	2·21
Núrpur	2,050	79·3	Gurdáspur	900	30·1	1,150	2·60
Dehra (Tahsil)	2,230	74·7	Roorkee	890	41·2	1,340	1·79
Do. observatory	2,230	83·3	Ditto	890	37·6	1,340	2·21
Bhogpur	2,450	157·6	Ditto	890	35·1	1,560	4·42
Pálampur	4,000	118·0	Gurdáspur	900	28·7	3,100	4·11
Dharmsála	4,490	123·2	Ditto	900	33·1	3,590	3·72
Mussooree (1)	5,830	142·2	Roorkee	890	32·0	4,940	4·44
Mussooree (2)	6,550	92·1	Ditto	890	41·5	5,660	2·22
Naini Tál, Convalescent Depôt ...	6,300	110·9	Rudarpur	720	49·6	5,580	2·26
Do. (Tahsil)	6,600	92·0	Do.	720	43·6	5,880	2·11
Simla	6,950	68·6	Ambála	820	36·2	6,130	1·90
Chakráta	7,050	62·7	Sahâranpur and Ambála, ...	890	36·4	6,360	1·72
Landaur	7,510	87·1	Roorkee	890	42·5	6,620	2·05
Níti	11,460	5·5	Roorkee and Rudarpur ...	800	45·0[1]	10,660	0·12

[1] Rainfall of July, August, and September, 1849: the observations at Níti taken by General Strachey.

By grouping together the ratios for the places lying between the even thousands of feet, many of the irregularities that appear in Table XVIII are cleared away, and the results may be accepted with more confidence. The excessive rainfall of Bhogpur, for example, will to some extent counterbalance the defect at Dehra caused by the position of the latter station behind the ridge of the Siwáliks. The following figures are thus obtained :—

Height above plain.	Mean height.	Rainfall ratio.	
		Observed.	Calculated.
	Feet.		
0 to ... 1,000 Feet.	435	1·61	1·67
1,000 „ ... 2,000 „	1,300	2·65	2·71
3,000 „ ... 4,000 „	3,350	3·91	3·77
4,000 „ ... 5,000 „	4,730[1]	3·46	3·34
5,000 „ ... 6,000 „	5,710	2·20	2·48
6,000 „ ... 7,000 „	6,370	1·69	1·65
10,000 „ ... 11,000 „	10,660	0·12	?

The ratios in the last column are calculated by means of a formula, $R = 1 + 1{\cdot}65h - 0{\cdot}24h^2$. It represents the observed ratios in the above table up to 6,500 feet as closely as can possibly be expected, considering the nature of the observations. At elevations greater than 7,360 feet above the plain, this formula gives negative values for the rainfall, and is therefore inapplicable; but from 6,000 feet above the plain upwards, the rainfall ratio may be approximately represented by a logarithmic formula, $\log R = 2{\cdot}050 - 0{\cdot}278\,h$. In both formulæ h is to be expressed in thousands of feet.

The mean rainfall along Rohilkhand and the Doáb, at a distance of twenty miles from the hills, is about 43 inches, and the mean elevation of this line above sea-level is 800 feet. Applying the formulæ in the preceding paragraph to these data, we find that the average rainfall, on the southern slope of exposed mountain ridges, in Kumáun and Garhwál would probably be the following :—

At	800	feet above the sea	43	inches.
„	1,000	„ „	57	„
„	2,000	„ „	113	„
„	3,000	„ „	149	„
„	4,000	„ „	164	„
„	5,000	„ „	159	„
„	6,000	„ „	133	„
„	7,000	„ „	91	„
„	8,000	„ „	54	„
„	9,000	„ „	28	„
„	10,000	„ „	15	„
„	11,000	„ „	8	„
„	12,000	„ „	4	„

[1] The observations for the lower Mussooree station being for a very short period only, the figures for the stations immediately above and below it in Table XVIII have been included in striking the average.

From the table it appears that the maximum rainfall occurs about 4,000 feet above the sea. The exact height of the maximum zone determined by the formula is 3,438 feet above the plain, of about 4,240 above sea-level. This agrees very closely with the mean altitude at which a rising column of air reaches its dew-point in the rainy season.

By far the most important, if not the only cause of rain in the Himálaya is the cooling of the air by expansion as it ascends the mountain slope. It has been already seen that, in the rainy season, the direction of the wind, at all elevations in the Himálaya up to 15,000 or 16,000 feet, if not higher still, is from some southerly quarter. Near the foot of the hills, the prevailing direction is south-easterly, but at most of the stations, from the level of Dehra Dún upwards, the wind blows from some point to the west of south; that is, more or less nearly at right angles to the axis of the mountain zone. The air, in rising to surmount the barrier, has its heat rapidly converted into the work of expansion, and it commences to precipitate rain when the temperature falls to the dew-point. When once condensation begins, the rate of decrease of vapour with height will be a measure of the quantity condensed, or the rainfall. This rate is greatest at the lowest elevations; and thus rain should be heaviest at places on the outer slope of the mountains, where a rising stream of air usually begins to precipitate moisture, as the observations prove to be the fact.

The slight rainfall of places like Almora and Srinagar, to the leeward of a higher mountain mass, is caused by the partial exhaustion of the vapour in crossing the mountains and by the dynamical heating of the air as it streams down towards the valley, both causes diminishing the tendency to condensation. The rapid decrease of rainfall, on ascending beyond 6,000 or 7,000 feet, is due simply to the exhaustion of the vapour, but, at all elevations, the influence of high ranges, in cutting off the supply of vapour, is easily seen. Regarding the rainfall of 1849 on the Tibetan table-land, General Strachey says:—"In the country beyond Níti no register was kept; but during a week of rainy weather in the middle of August 1·5 inches fell at Níti, while at Sanjar, beyond the watershed, where I was then encamped, at 16,500 feet, the rain never exceeded a very faint drizzle, and could hardly have been susceptible of measurement." At the Leh observatory, all through the summer, the rainfall hardly ever exceeds a few drops, and the greatest fall in a month, during several years, was an inch and a half. Sir Joseph Hooker's experience in Sikhim supplies us with facts quite parallel to these. In August, 1849, he says 26·8 inches fell at Darjíling, while in the interior, at the same elevation, but in the rear of the first masses of snowy mountains, only 12·5 inches were measured. Between the 8th of September and the end of the month, only 1·7 inches fell at Mome Samdong, about 15,500 feet above the sea, while at Darjíling 10 inches fell, and other instances of a similar nature might be cited.

The variation of rainfall with season is very distinctly marked in India. At all the stations in Tables XVIII and XIX, and at almost every station on the North Indian plain, the driest month of the year is November. In the great majority of years no precipitation whatever occurs in this month, or in the first half of December; except perhaps on the higher mountains towards the north-west, where the winter snows begin before the end of November. About Christmas, a few showers of snow usually fall on the outer hills, and at the same time there is a slight precipitation of rain over the plains of the Panjáb and the North-Western Provinces. These winter snows and rains

increase in quantity and in frequency on the hills and in the north-west Panjab, until February or March, but on the plains of the North-Western Provinces and Behar the maximum occurs in January.

The cause of the winter rains and snows has already been pointed out in describing the annual changes of the winds. In October and about the beginning of November, the air over Northern India is as near as it ever attains to a condition of statical equilibrium. It is subject to the diurnal oscillations called the barometric tides and to the accompanying mountain winds, but there is little permanent movement of the air in any direction. During the cold weather, however, the neutral plane of pressure gradually sinks and the south-west upper currents of the atmosphere are then forced to ascend the slope of the mountains where they precipitate more or less of the vapour they contain. On the lower hills, the temperature increases so rapidly in March and April, that the tendency to precipitation, and consequently the rainfall, becomes less than in January and February, though the upper currents continue to blow from nearly the same direction as in winter. Along the southern declivity of the great snowy range, however, thunderstorms are of daily occurrence at this time of the year; and above the snow line considerable quantities of snow are frequently precipitated. In Ladákh, the heaviest falls of snow, observed by Captain H. Strachey in 1848-49, occurred in April; but during the three years, 1876-78, there was no precipitation at Leh in that month.

April and May are the months in which hail is most frequently noticed in the Himálaya. No regular registers of this phenomenon have been kept; but, nearly every year, several hailstorms occur in the outer hills, and the stones are often of large size. On the 11th of May, 1855, a hailstorm occurred at Naini Tál, in which many stones of 6, 8, 10, and even 24 ounces were observed to fall, the circumference of these varying from 9 to 13 inches. In 1878 there was a storm in which large hailstones fell, some of them so heavy that they punched holes through the zinc roofs of the houses, while the quantity was so great that it lay in shady places, where covered with leaves, for nearly a month.

About the middle of June usually, and sometimes before the end of May, near the foot of the hills, the hot north-west winds of the plains give way to sea winds from the Bay of Bengal. The whole of the lower atmosphere over India is then moving towards the Himálaya; and the upward deflection of the air currents by the mountains causes frequent precipitations of rain, in the manner already described. The rainy season almost always commences sooner on the mountains than on the plains; for saturation is reached first at high elevations, and then propagated downwards, by the cooling effect of the falling rain drops and the cutting off of the sun's heat by clouds. At most places in India, and in the inner parts of the Himálaya, July is the rainiest month; but on the outer slope of the mountains, August is equally or sometimes even more rainy, especially towards the north-west of the chain.

While the rainy season lasts, the parts of Ladákh about Leh, and the Tibetan plateau generally, receive perhaps, on the whole, less precipitation than in winter; because the temperature is then so much higher than on the Indian side of the chain; this high temperature greatly decreasing the relative humidity of any air that may reach the plateau from the south. It is probable also that the high snowy peaks, lying above the limit of the monsoon current proper, receive less precipitation in summer than in winter. At the turn of the seasons, however, about the end of September, falls

of snow, amounting to several feet in thickness, sometimes occur on the passes over the Indian watershed.

Shortly after the autumnal equinox, about the end of September or beginning of October, the rains cease all over Northern India. The sudden cessation of the rainy season seems to be in some measure determined by the rapid diminution of solar heat, as the sun retreats to the south of the equator. It is possibly to this that we must attribute the somewhat remarkable regularity of the recurrence of two or three days' incessant rain frequently experienced in Kumáun about the 20th of September. On the plains, also, it is well known to the natives of the country that if rain falls in the *nakshatra* (lunar mansion) of *Hathiya*—that is, in the last week of September or first week of October, it is likely to be heavy. Excessively heavy rain, like that of the 17th and 18th September, 1880, when 30 inches fell in little more than two days at Nani Tál, and produced a disastrous landslip, cannot, however, be thus produced by a simple loss of heat, but requires a powerful indraught of moist air to keep up the supply of vapour. The heavy rain observed on the plains at "the break-up of the monsoon," and probably also that which falls at the same time on the outer hills of Kumáun, must be due chiefly to the minor storms of a cyclonic character that are frequently formed near the head of the Bay of Bengal at the turn of the season, and pass inland in a north-westerly direction.

Additional Note on the Distribution of Vapour.

In the hot weather of the present year (1881), I spent the greater part of two months' leave in the Himalayas, and while there I took frequent observations with the psychrometer, the results of which serve, in some degree, as a test of the truth of the ratios for the first 13,000 feet, given in Table XV under Kumáun. Unfortunately, the greatest elevation I attained was only 13,800 feet; and the ratios for 14,000 to 18,000 feet, which are believed by General Strachey to be somewhat too small, must be accepted as they stand in the table.

The thermometers, used for the observations, were small pea-bulb instruments by Casella, mounted in a mahogany case, the lid of which was opened and the muslin over the wet bulb moistened several minutes before taking an observation. The box was usually hung up in the best shade available—in the verándah of a house, in a cattle shed open all round, or under a tree. Where the shade was imperfect or the air was quite still, the box was swung gently backwards and forwards until the indication of each thermometer became steady. The pressures were taken from a small pocket aneroid corrected after every considerable change of level by comparison with a mountain barometer. From these pressures, the heights of most of the places have been calculated approximately, the reference station being Ranikhet for all the places east of Pauri, and Dehra for places west of Pauri. A few of the elevations about Naini Tal, Mussooree, and Dehra, have been taken from the maps of the Great Trigonometrical Survey.

The observations of the psychrometer have been reduced by August's formula with Regnault's constants. Observations of one of Regnault's condensing hygrometers were made at Naini Tal, Ranikhet, Badrináth, and Dobri, and though the degree

of humidity at the times of observation was low—ranging from 22 per cent. at Ranikhet to 56 per cent. at Dobri—the results of the direct observations agree very closely with those given by the formula. For higher degrees of humidity the agreement must be still closer. The observations indicate that a great variety of weather was experienced on the journey, the degree of humidity ranging from 12 to 96 per cent. The mean rate of variation of vapour with height, deduced from these observations, will therefore probably approach closely to the average rate for the summer months.

The tension of vapour at sea-level, for each day, has been found from the observations made at Bareilly and Roorkee at 10 A.M. and 4 P.M.; hourly observations made at Roorkee, indicating that these differ little from the mean of 24 hours. The process of reduction employed is that described at page 406. The resulting values have been smoothed, by taking the mean for each period of seven consecutive days, in order to eliminate as far as possible the effect of changes of weather of short period. In computing the ratios, in the last column but one of the first table appended to this note, all the observations made at one place, in a single day, have been counted as one, the mean of them all being divided by the tension at sea-level for that day.

The ratios in this column may be grouped together by taking the average of them all for places between 500 and 1,500 feet, 1,500 and 2,500 feet, &c., additional weight being given, when necessary, to certain places, preferably those where several observations have been made, in order that the average height may be as nearly as possible an even thousand of feet. In this way we get the following values:—

Height.	Vapour Tension ratio observed.	Vapour Tension ratio computed.	Difference.
Sea-level	1·000	1·000	...
1,000 feet	·879	·903	+.024
2,000 "	·830	·815	—·015
3,000 "	·761	·736	—·025
4,000 "	·680	·664	—·016
5,000 "	·608	·600	—·008
6,000 "	·553	·542	—·011
7,000 "	·531	·489	—·042
8,000 "	·455	·441	—·014
9,000 "	·371	·398	+·027
10,000 "	·330	·360	+·030
11,000 "	·295	·324	+·029
12,000 "	·268	·293	+·025
13,000 "	·258	·265	+·007
13,800 "	·260	·244	—·016

The figures in the last column but one are computed by the formula log. p=log. P—$\frac{h}{22036}$. The numerical constant is thus somewhat less than that deduced from all the observations given in Table XV. The column of differences shows that, the computed ratios are generally less than those, given by observation, at elevations below 9,000 feet and greater at higher elevations, as in the Kumáun series in Table XV; but the excess at 2,000 feet, in the column of observations, is much less than in Table XV. The

latter is due entirely to the local influence of Dehra. When the constant is computed for each 7,000 feet, the following values are obtained :—

Elevation.			Constant.
0 to 7,000	feet	... ...	25,163
1,000 to 8,000	„	... ...	21,477
2,000 to 9,000	„	... ...	20,617
3,000 to 10,000	„	... ...	19,291
4,000 to 11,000	„	... ...	19,800
5,000 to 12,000	„	... ...	18,974
6,000 to 13,000	„	... ...	22,251
7,000 to 13,800	„	... ...	21,927

The mean of these numbers is 21,463, almost the same as Dr. Hann's result, but the constant computed from the two extremes in the preceding table is 23,588. The number now adopted, 22,526, is the arithmetical mean of these two.

The constants computed for intervals of 7,000 feet decrease pretty regularly as the height increases, all except the last two. The whole of the observations, about 13,000 and 13,800 feet, were made, however, in the day time, when the tension of vapour at these elevations is above the daily mean, whereas at the lower elevations some of the observations were made in the early morning.[1] It seems probable therefore that a temperature constant should enter into the vapour tension formula as into the barometric formula; and there should probably be also a factor for the rate of decrease of temperature with height. The data here given do not, however, enable us to compute the value of these factors with any approach to exactness. The more rapid the variation of temperature, the smaller will the constant of the logarithmic formula be; and as the decrease of temperature is much more rapid in May and June than on the average of the year, the constant computed from observations made in these months is less than that calculated from Table XV, though the mean temperature in these months is higher.

Since this paper was in print, I have also worked up the numerous hygrometrical data contained in the "Hypsometry" volume of the Messrs. Von Schlagintweit.

The vapour tensions deduced from the temperatures and relative humidities, given in this volume, are, however, very irregular, and in many cases almost impossible. When compared with the mean results of the nearest Sub-Himálayan observatories, they give a series of ratios best represented by a logarithmic formula with the constant 19,700 feet. This is so much less than the constants given by other series of observations in the Himálaya that it must be considered erroneous.

[1] Dr Hann, in the paper referred to in page 408, finds that C increases slowly with the height. He notices, however, that the Himálayan observations would give a greater value for C than any of the others, probably owing to the higher temperature.

Psychrometric Observations in the Himálayas, 1881.

Date.	Hour.	Place.	Elevation above the Sea.	Barometer.	Dry bulb.	Wet bulb.	Relative Humidity.	Vapour tension.	Tension at Sea-level.	Ratio.	Weather Remarks.
April 28th to June 25th.	10 A.M. & 4 P.M.	Bareilly ...	568	Taken at 29·70	93·9	76·4	43	·680[1]	·722	·94	
Ditto ...	Ditto ...	Roorkee ...	887		94·6	74·8	37	·615[1]	·722	·85	
April 29th ...	5-30 A.M.	Ranibagh ...	1,720	28·10	70·8	56·7	37	·284	·319	·89	
" " ...	8-30 A.M.	Gájar ...	3,580	26·28	84·6	59·9	18	·214	·319	·67	
" " ...	9-15 A.M.	Douglas Dale ...	4,160	25·75	80·9	58·2	21	·224	·319	·70	
" " ...	10-5 A.M.	Nani Tal Brewery ...	4,590	25·44	85·9	61·7	22	·273	·319	·85	
" " ...	2-30 P.M.	Ditto Dâk Bungalow	6,600	23·51	73·8	54·4	27	·223	·319	·70	
" 30th ...	8-30 A.M.	Ditto Ditto ...	...	23·57	69·2	50·9	24	·175			
" " ...	3-15 P.M.	Ditto Ditto ...	...	23·60	71·7	54·4	32	·252	·303	·72	
" " ...	5-30 P.M.	Ditto Ditto ...	...	23·65	68·7	52·6	32	·228			
May 1st ...	10-30 A.M.	Ditto Ditto ...	...	23·70	73·3	56·0	32	·267	·302	·88	
" 2nd ...	Noon ...	Ditto St.-Loo Pass	7,390	23·15	63·6	43·1	12	·070	·314	·22	Strong wind.
" " ...	1-30 P.M.	Broken bridge 5 miles north of St. Loo.	4,700	25·21	78·8	53·2	12	·119	·314	·28	
" " ...	5-30 P.M.	Khairna Dâk Bungalow	3,240	26·50	78·8	54·7	14	·136	·314	·43	
" 3rd ...	5-30 A.M.	Ditto Ditto ...	...	26·57	63·1	50·9	40	·231	·324	·71	
" " ...	8-45 A.M.	Bukni Mahadeo ...	3,240	26·55	67·2	53·2	36	·243	·324	·75	
" " ...	11-45 A.M.	Pilkholi ...	5,230	24·72	67·7	51·2	29	·197	·324	·61	
" " ...	3-30 P.M.	Ranikhet Dâk Bungalow	5,720	24·25	72·8	51·2	17	·188	·324	·58	
" 4th ...	10 A.M. .	Ditto Ditto .	...	24·32	68·7	50·7	24	·171	·348	·49	
" " ...	11 A.M. ...	Ditto Observatory...	6,069	24·10	70·5	51·8	22	·165	·348	·47	
" " ...	1-30 A.M.	Ditto Dâk Bungalow	5,720	24·30	73·8	52·2	18	·152	·348	·47	
" " ...	7 P.M. ...	Ditto Ditto ...	...	24·35	66·4	49·9	27	·177			
" 5th ...	5-30 A.M.	Ditto Ditto ...	...	24·35	59·2	47·1	38	·191	·373	·51	
" " ...	7 A.M. ...	Kotla ...	4,850	25·16	66·7	51·7	33	·217	·373	·58	
" " ...	9 A.M. ...	Darmár Bridge ...	3,450	26·46	70·9	57·7	43	·324	·373	·87	
" " ...	10 A.M. ...	Sanoli ...	3,650	26·27	81·9	58·9	21	·229	·373	·61	
" " ...	4 P.M. ...	Dwárahát Dâk Bungalow	4,980	24·99	80·6	56·7	19	·195	·373	·52	
" 6th ...	5 A.M. ...	Ditto Ditto ...	...	25·02	67·7	52·5	34	·228	·435	·52	
" " ...	7 A.M. ...	Road, 4 miles north of Dwara.	3,490	26·36	68·0	54·2	38	·260	·435	·60	
" " ...	10-30 A.M.	Ganai Dâk Bungalow ...	3,060	26·75	82·9	60·7	23	·265	·435	·69	
" " ...	3-45 P.M.	Ditto Ditto ...	...	26·70	86·6	64·2	26	·333			
" 7th ...	8-40 A.M.	Mihalchauri Dispensary	4,020	25·88	73·8	61·2	47	·396	·516	·77	
" " ...	5-45 P.M.	Lohba Dâk Bungalow...	5,270	24·84	77·8	59·9	33	·318	·516	·62	
" 8th ...	5 A.M. ...	Ditto Ditto ...	...	24·85	66·7	58·7	55	·363	·562	·65	
" " ...	6-45 A.M.	Near pass, above Lohba	6,150	24·00	61·8	49·2	39	·217	·562	·39	
" " ...	10 A.M. ...	Waterfall above Athbadri.	4,520	25·43	83·4	66·2	39	·448	·562	·80	

[1] From the individual observations.

Psychrometric Observations in the Himálayas, 1881—contd.

Date	Hour.	Place.	Elevation above the Sea.	Barometer.	Dry Bulb.	Wet Bulb.	Relative Humidity.	Vapour tension.	Tension at Sea-level.	Ratio.	Weather Remarks.
May 8th ...	2 P.M. ...	Top Camp ...	3,410	26·30	100·8	74·7	28	·550	·562	·90	
" " ...	5 P.M. ...	Ditto ...	...	26·30	95·1	71·7	27	·439			
" 9th ...	7 A.M ...	Pindar River ...	2,500	27·24	69·7	64·5	74	·541	·600	·91	
" " ...	9-45 A.M.	Karnprayág Dispensary	2,610	27·12	85·4	73·7	56	·688	·600	1·00	
" " ...	4 P.M. ...	Ditto Ditto ...	...	27·08	93·8	71·5	32	·510			
" 10th ...	7 A.M. ...	Ditto Ditto ...	...	27·32	74·0	66·2	65	·549			
" " ...	9-30 A.M.	Ditto Ditto ...	...	27·36	85·8	69·3	42	·514	·626	·88	
" " ...	Noon ...	Ditto Ditto ...	...	27·12	97·0	72·7	28	·506			
" " ...	3-30 P.M.	Ditto Ditto ...	...	27·12	77·3	69·7	68	·634			Raining.
" 11th ...	5-20 A.M.	Ditto Ditto ...	...	27·37	64·8	63·7	95	·578	·659	·88	
" " ...	12-15 P.M.	Nandprayág ...	2,810	27·08	84·4	71·9	53	·630			
" " ...	2-30 P.M.	Ditto ...	...	26·94	91·3	70·3	32	·486	·659	·82	
" " ...	6-15 P.M.	Ditto ...	...	27·00	82·5	67·7	44	·499			
" 12th ...	9 A.M. ...	Chamoli Dispensary ...	3,160	26·80	77·0	64·7	60	·464			
" " ...	2 P.M. ...	Ditto ...	...	26·70	78·3	67·5	55	·545	·674	·83	
" " ...	4 P.M. ...	Ditto ...	...	26·67	75·1	68·8	72	·630			
" " ...	6-50 P.M.	Ditto ...	...	26·65	74·7	67·7	69	·595			
" 13th ...	5 A.M. ...	Ditto ...	...	26·80	67·8	64·3	83	·562	·681	·85	
" " ...	9 A.M. ...	Pipalkoti ...	4,380	25·62	67·4	61·9	69	·464	·681	·66	
" " ...	11-15 A.M.	Ditto ...	...	25·61	69·2	60·9	62	·410			
" " ...	4 P.M. ...	Syálgárh ...	3,960	25·86	75·7	63·8	52	·465	·681	·70	
" " ...	6-45 P.M.	Ditto ...	...	25·87	72·8	63·7	60	·496			
" 14th ...	9 A.M. ...	Hilang ...	5,340	24·79	66·7	60·9	71	·472	·685	·61	
" " ...	11-50 A.M.	Ditto ...	...	24·70	78·6	61·5	36	·358			
" " ...	5-15 P.M.	Joshimath ...	6,130	24·00	64·6	57·2	64	·391	·685	·57	Raining.
" 15th ...	7 A.M. ...	Ditto ...	...	24·04	60·9	57·0	79	·425			
" " ...	10-50 A.M.	Ditto ...	...	24·01	65·7	60·2	73	·464			
" " ...	1-20 P.M.	Ditto ...	...	23·98	70·9	57·6	44	·332	·690	·55	
" " ...	4 P.M. ...	Ditto ...	...	23·96	69·7	56·6	44	·320			
" " ...	6-30 P.M.	Ditto ...	...	23·98	65·2	56·3	56	·359			
" " ...	5-30 A.M.	Ditto ...	...	24·00	58·9	50·5	65	·323	·700	·46	
" " ...	6-20 A.M.	Vishnuprayág ...	4,520	25·32	60·1	54·5	70	·364	·709	·51	
" " ...	Noon ...	Pandukeswar ...	6,330	23·88	74·6	57·6	34	·295			
" " ...	3 P.M. ...	Ditto ...	...	23·75	74·8	58·7	38	·325	·709	·48	
" " ...	6-30 P.M.	Ditto ...	...	23·76	71·7	60·2	51	·400			
" 17th ...	5-10 A.M.	Ditto ...	...	23·84	59·8	53·5	67	·344	·711	·48	

Psychrometric Observations in the Himálayas, 1881—contd.

Date.	Hour.	Place.	Elevation above the Sea.	Barometer.	Dry Bulb.	Wet Bulb.	Relative Humidity.	Vapour tension.	Tension at Sea-level.	Ratio.	Weather Remarks
May 17th ...	6 20 A.M.	Hacháchará ...	6,950	23·34	54·1	49·7	74	·312	·711	·48	
" " ...	7 A.M. ...	2nd Bridge over Vishnu-ganga.	7,330	23·04	52·6	49·5	80	·323	·711	·45	
" " ...	8 A.M. ...	Diwángani ...	7,770	22·68	54·6	49·7	72	·308	·711	·43	
" " ...	9-30 A.M.	Hanumán Chatti ...	8,220	22·22	64·4	54·7	55	·333	·711	·47	
" " ...	10 A.M. ...	3rd Bridge ...	8,730	21·95	64·6	53·6	50	·305	·711	·43	
" " ...	10-45 A.M.	4th Bridge ...	8,860	21·78	63·6	51·6	45	·267	·711	·37	
" " ...	Noon ...	Great Snow Bridge, 1 mile below Badri.	9,850	20·91	61·4	51·2	43	·262	·711	·37	
" " ...	1-30 P.M.	Badrináth, Field above Temple.	10,240	20·55	67·2	47·7	23	·154			
" " ...	3-40 P.M.	Ditto ...	...	20·59	59·2	49·7	55	·271	·711	·34	
" " ...	7 P.M. ...	Ditto ...	...	20·63	51·6	48·2	72	·307			
" 18th ...	6 A.M. ...	Ditto ...	...	20·65	43·8	37·8	61	·174	·714	·24	
" " ...	6-30 A.M.	Hills west of Badri ...	10,540	20·42	44·6	39·6	60	·199	·714	·28	
" " ...	7-45 A.M.	Ditto ...	11,430	19·75	58·1	46·7	43	·209	·714	·29	
" " ...	8-20 A.M.	Ditto ...	11,960	19·39	56·1	42·6	35	·158	·714	·22	
" " ..	9-15 A.M	Ditto ...	12,390	19·07	57·4	43·8	36	·171	·714	·24	
" " ...	10 A.M. ...	Ditto ...	12,770	18·84	55·1	42·4	38	·166	·714	·23	
" " .	10-30 A.M.	Ditto ...	13,150	18·58	56·6	43·8	40	·182	·714	·26	
" " .	11-10 A.M.	Ditto ...	13,340	18·45	52·6	42·6	48	·192	·714	·27	
" " ...	11-45 A.M.	Ditto ...	13,800	18·14	49·9	40·8	50	·183	·714	·26	
" " ...	12-30 P.M.	Ditto ...	13,060	18·66	59·6	44·4	41	·212	·714	·30	
" " ...	1 P.M. ...	Ditto ...	12,280	19·21	59·6	47·7	45	·231	·714	·32	
" " ...	1-30 P.M.	Ditto ...	11,410	19·81	59·8	48·3	46	·239	·714	·33	
" " ...	3 P.M. ...	Badrináth ...	10,240	20·55	62·6	49·2	42	·228	·714	·39	Rain, thunderstorm.
" " ...	6 P.M. ...	Ditto ...	...	20·66	53·4	49·8	80	·326			
" 19th ...	8 A.M. ...	Ditto ...	...	20·64	53·3	44·1	50	·206			
" " ...	11 A.M. ...	Ditto ...	...	20·60	59·6	45·3	34	·173			
" " ...	1 P.M. ...	Ditto ...	...	20·61	58·5	46·1	41	·200	·720	·28	
" " ...	3 P.M. ...	Ditto ...	...	20·67	48·6	42·1	61	·209			
" " ...	5-40 P.M	Ditto ...	...	20·66	46·6	41·6	69	·218			Rain.
" 20th ...	6-50 A.M.	Ditto ...	...	20·73	40·1	34·6	60	·151	·701	·21	
" " ...	9 A.M. ...	Snow Bridge ..	9,850	21·02	60·1	46·1	35	·183	·701	·26	
" " ...	9-45 A.M.	4th Bridge over Vishnu-ganga.	8,860	21·73	64·2	50·1	38	·227	·701	·32	
" " ...	10-10 A.M.	3rd ditto ..	8,730	21·96	66·7	50·2	31	·203	·701	·29	
" " ...	10-30 A.M.	Hanumán Chatti ...	8,220	22·15	69·4	51·9	30	·215	·701	·31	
" " ...	11-25 A.M.	Diwangani -	7,770	22·50	73·8	53·9	26	·216	·701	·31	
" " ...	12-15 P.M.	2nd Bridge ...	7,330	22·85	72·8	56·1	35	·281	·701	·40	
" " ...	12-50 P.M.	Hacháchará ...	6,950	23·20	75·8	56·3	28	·253	·701	·36	

Psychrometric Observations in the Himálayas, 1851—contd.

Date.		Hour.	Place.	Elevation above the Sea.	Barometer.	Dry Bulb.	Wet Bulb.	Relative Humidity.	Vapour tension, e.	Tension at Sea-level.	Ratio.	Weather Remarks.
May 20th	...	6 P.M. ...	Pandukeswar ...	6,330	23·73	76·6	62·9	46	·424	·701	·60	
„ 21st	...	5-30 A.M.	Ditto ...	...	23·80	56·4	50·3	65	·298	·672	·45	
„ „	...	9-30 A.M.	Vishnuprayág ...	4,520	25·49	71·2	56·5	38	·291	·662	·44	
„ „	...	1-30 P.M.	Joshimath ...	6,150	23·96	71·7	56·9	39	·306	·662	·46	
„ 22nd	...	7 A.M. ...	Ditto ...	...	24·02	63·6	51·2	54	·321			
„ „	...	10 A.M. .	Ditto ...	...	24·00	70·7	57·7	45	·339			
„ „	...	1-30 P.M.	Ditto ...	...	23·96	74·4	58·3	37	·316	·654	·45	
„ „	...	4 P.M. ...	Ditto ...	...	23·97	71·2	54·5	32	·248			
„ „	...	6-30 P.M.	Ditto ..	...	24·01	69·7	53·9	34	·248			
„ 23rd	...	5-40 A.M.	Ditto ..	...	24·01	60·1	53·7	66	·345	·623	·51	
„ „	..	7-45 A.M.	Ditto ...	...	24·02	61·6	52·7	64	·294			
„ „	...	3 P.M. ...	Gulábkot ...	5,080	24·83	68·9	61·2	64	·456	·623	·73	Slight rain.
„ „	...	7-30 P.M.	Syálgárh ...	3,960	25·77	67·7	61·5	70	·476	·623	·76	
„ 24th	...	9 A.M. ...	Hát ...	3,700	26·19	72·4	62·2	55	·441	·604	·73	
„ „	...	1-45 P.M.	Chamoli ..	3,160	26·58	70·4	66·1	79	·591	·604	·98	Drizzle.
„ 25th	...	9 A.M. ...	Ditto ...	...	26·61	66·2	62·7	82	·528	·572	·91	Heavy rain.
„ „	...	1 P.M. ...	Ditto ...	...	26·48	78·6	66·7	52	·513			
„ 26th	...	9-45 A.M.	Karnprayág .	2,610	27·22	76·8	66·7	56	·532			
„ „	...	11-30 A.M.	Ditto ...	...	27·10	85·7	67·3	36	·444	·579	·79	
„ „	...	3-45 P.M.	Ditto ...	...	26·96	85·9	65·5	31	·390			
„ 27th	...	6-30 A.M.	Chatwápipal ...	2,160	27·28	70·7	60·4	53	·400	·614	·65	
„ „	...	8-30 A.M.	Silkot ...	3,880	25·93	73·3	62·7	55	·447	·614	·73	
„ „	...	2 P.M. ...	Sidoli ...	4,870	24·92	85·1	66·7	37	·449	·614	·62	
„ „	...	5-15 P.M.	Ditto ...	...	24·96	79·9	60·7	31	·318			
„ 28th	...	5-40 A.M.	Ditto ...	...	25·12	60·6	57·2	82	·432	·619	·70	
„ „	...	9-10 A.M.	Stream below Dhanpur	7,450	22·87	67·2	58·6	61	·406	·619	·65	
„ „	...	10 A.M. ...	Dhanpur ...	7,560	22·78	63·7	50·7	60	·421			
„ „	...	1-15 P.M.	Ditto ...	...	22·76	72·3	60·9	53	·419	·619	·62	
„ „	...	3 P.M. ...	Ditto ...	...	22·74	71·9	58·2	44	·348			
„ „	...	6 P.M. ..	Ditto ...	...	22·78	67·2	56·8	53	·357			
„ 29th	...	5-15 A.M.	Ditto ...	...	22·84	59·8	50·4	52	·272	·653	·42	
„ „	...	6-10 A.M.	Road above Dhanpur ...	8,170	22·27	55·6	53·2	86	·383	·653	·58	
„ „	...	7-20 A.M.	Pass ditto ...	9,300	21·35	57·1	51·7	71	·334	·653	·51	
„ „	...	10 A.M. ...	Dobri ...	7,990	22·46	66·8	57·7	55	·357			
„ „	...	11 A.M. ...	Ditto ...	...	22·45	68·5	58·6	56	·395	·653	·63	
„ „	...	3 P.M. ...	Ditto ...	...	22·38	73·0	60·3	49	·397			
„ „	...	6-30 P.M.	Ditto ...	...	22·45	66·7	60·8	72	·475			

Psychrometric Observations in the Himálayas, 1881—contd.

Date.	Hour.	Place.	Elevation above the Sea.	Barometer.	Dry Bulb.	Wet Bulb.	Relative Humidity.	Vapour tension.	Tension at Sea-level.	Ratio.	Weather Remarks.
May 30th ...	5 A.M. ...	Dobri ...	7,990	22·48	61·3	52·5	56	·308	·718	·43	
" " ...	8 A.M. ...	Bhainswára ...	6,650	23·59	69·2	58·5	53	·380	·718	·51	
" " ...	10 A.M. ...	Ditto ...	...	23·52	74·3	59·3	40	·348			
" " ...	Noon ...	Sioli ...	5,260	24·70	84·1	68·7	45	·531	·718	·74	
" " ...	4 P.M. ...	Paithání ...	4,200	25 56	89·1	71·4	41	·565	·718	·77	
" " ...	7-30 P.M.	Ditto ...	...	25·59	84·4	69·2	46	·539			
" 31st ...	4 A.M. ...	Ditto ...	...	25·71	70 8	65·4	75	·565	·770	·74	
" " ...	8 A.M. ...	Chiphalghát Dâk Bungalow.	3,770	26·02	80 9	69 0	54	·570			
" " ...	10 A.M. ...	Ditto ...	...	26·00	87·4	71·2	44	·574	·770	·69	Hot wind.
" " ...	1 P.M. ...	Ditto ...	...	25·94	95·6	71·7	31	·515			
" " ...	4 P.M. ...	Ditto ...	...	25·89	90·3	68·9	33	·465			
" " ...	7-30 P.M.	Choprion ...	4,010	25·77	78·5	63·8	44	·423	·770	·55	
June 1st ...	12-15 P.M.	Páuri (Chopra) ...	5,230	24·79	79·3	60·7	32	·325	·824	·38	
" " ...	4 P.M. ...	Ditto ...	...	24·77	80·7	60·5	29	·304			
" 2nd ...	10 A.M. ...	Ditto ...	...	24·77	78·3	68·2	60	·578	·850	·68	Shower.
" 3rd ...	7 A.M. ...	Khandá Nadi ...	2,080	27·48	77·3	73·7	83	·787	·866	·91	
" " ...	9 A.M. ...	Srinagar ...	1,530	28·05	87·7	74·3	52	·679			
" " ...	4-30 P.M.	Ditto ...	...	27·90	96·8	77·5	42	·699	·866	·78	
" " ...	7-10 P.M.	Ditto ...	...	27·93	92·7	74·9	42	·611			
" 4th ...	4 A.M. ...	Ditto ...	...	28 06	87·9	78 0	63	·834	·914	·91	
" " ...	10-30 A.M.	Takoli ...	2,530	27·02	94·6	76·7	43	·699			
" " ...	4 P.M. ...	Ditto ...	...	26 98	94·8	75·2	38	·628	·914	·72	
" " ...	7 P.M. ...	Ditto ...	...	27·04	89·6	74·3	47	·662			
" 5th ...	3-15 A.M.	Ditto ...	...	27·13	80 9	73·7	71	·744	·942	·79	
" " ...	7 A.M. ...	Pau Dharmsála ...	4,020	25·75	78·2	71·5	73	·716			Raining.
" " ...	9-30 A.M.	Ditto ...	...	25·73	85·6	74·6	59	·730	·942	·75	
" " ...	4 P.M. ...	Ditto ...	...	25·61	87·9	74·3	52	·692			
" 6th ...	3-45 A.M.	Ditto ...	...	25·71	79·3	71·7	69	·690	·947	·74	
" " ...	8-15 A.M.	Tihri Bungalow ...	1,740	27·95	80·9	70·7	59	·624			
" " ...	11-45 A.M.	Ditto ...	...	27·89	82·9	74·2	65	·737	·947	·74	Shower.
" " ...	5-30 P.M.	Ditto ...	...	27·83	90 6	75·7	49	·702			
" 7th ...	6-30 A.M.	Ditto ...	...	27·86	83·4	74·4	64	·739			
" " ...	10-30 A.M.	Ditto ...	...	27·94	80·4	73·7	72	·749	·954	·78	Slight rain.
" " ...	1 P.M. ...	Ditto ...	...	27·86	81·3	73·7	69	·737			
" " ...	6 P.M. ...	Ditto ...	...	27·84	82·8	74·8	68	·763			
" 8th ...	6 A.M. ...	Ditto ...	...	27·96	78·7	74·7	82	·811	·965	·82	Heavy rain & thunder.
" " ...	9-30 A.M.	Ditto ...	...	28·06	75·4	72·9	88	·779			

Psychrometric Observations in the Himálayas, 1881—contd.

Date.	Hour.	Place.	Elevation above the S.S.	Barometer.	Dry Bulb.	Wet Bulb.	Relative Humidity.	Vapour tension.	Tension at sea level.	Ratio.	Weather remarks.
June 8th ...	6-30 P.M.	Kauringalia Bungalow...	6,620	23·55	66·8	62·5	79	·521	·975	·54	
„ 9th ...	11 A.M. ...	Dhanaulti ditto ...	7,750	22·69	66·2	64·2	90	·582			Showers.
„ „ ...	4 P.M. ...	Ditto ...	...	22·65	66·2	63·7	89	·577	·978	·59	
„ „ ...	7 P.M. ...	Ditto ...	...	22·65	63·4	62·7	96	·564			Drizzling.
„ 10th ...	5 A.M. ...	Ditto ...	...	22·66	60·6	59·8	96	·505	1·001	·51	
„ „ ...	7-30 P.M.	Mussoorie Hotel ...	6,480	23·61	66·9	63·2	82	·542	1·000	·54	
„ 11th ...	10-30 A.M.	Ditto ...	...	23·63	67·2	63·3	81	·542	1·007	·54	
„ „ ...	3-30 P.M.	Ditto ...	...	23·58	67·7	63·7	81	·549			
„ 12th ...	8 A.M. ...	Ditto ...	...	23·60	67·6	63·2	78	·534	1·019	·52	
„ 13th ...	9-30 A.M.	Ditto ...	...	23·63	67·9	65·2	87	·595			
„ „ ...	3 P.M. ...	Ditto ...	...	23·60	68·7	67·8	95	·672	1·034	·62	
„ „ ...	6 P.M. ...	Ditto ...	...	23·57	68·9	67·3	93	·654			
„ 14th ...	11 A.M. ...	Ditto ...	...	23·64	67·7	65·5	89	·606	1·033	·58	
„ „ ...	6-30 P.M.	Ditto ...	...	23·54	69·3	65·7	83	·596			
„ 15th ...	9-30 A.M.	Ditto ...	...	23·56	69·4	66·4	86	·616	1·022	·62	Rain.
„ „ ...	5 P.M. ...	Ditto ...	...	23·51	69·7	67·7	90	·658			
„ 16th ...	8-15 A.M.	Ditto ...	...	23·57	66·3	63·7	87	·564	·981	·61	
„ „ ...	4-15 P.M.	Ditto ...	...	23·55	70·2	67·5	87	·616			
„ 17th ...	3-30 P.M.	Ditto ...	...	23·56	67·7	65·2	86	·596	·952	·63	Ditto.
„ 18th ...	11 A.M. ...	Ditto ...	...	23·60	68·5	67·0	93	·647	·927	·64	
„ „ ...	5 P.M. ...	Ditto ...	...	23·54	51·7	65·0	70	·548			
„ 19th ...	6-10 A.M.	Ditto ...	...	23·56	68·2	55·5	56	·398	·884	·50	
„ „ ...	2-20 P.M.	Ditto ...	...	23·59	73·3	63·2	58	·457			
„ 20th ...	7-45 A.M.	Ditto ...	...	23·62	67·1	61·2	71	·471	·837	·63	
„ „ ...	3-30 P.M.	Ditto ...	...	23·61	69·7	65·9	82	·589			
„ 21st ...	8 A.M. ...	Ditto ...	...	23·69	66·2	61·7	78	·504	·817	·68	Continuous rain.
„ „ ...	3-15 P.M.	Ditto ...	...	23·69	71·7	66·9	78	·613			
„ 22nd ...	11 A.M. ...	Ditto ...	...	23·65	68·2	66·8	93	·644			
„ „ ...	4-30 P.M.	Ditto ...	...	23·61	72·8	64·6	65	·515	·832	·67	
„ „ ...	10 P.M. ...	Ditto ...	...	23·62	70·3	63·5	70	·517			
„ 23rd ...	7-30 A.M.	Ditto ...	...	23·61	67·5	62·8	77	·526	·861	·62	
„ „ ...	5 P.M. ...	Ditto ...	...	23·59	71·9	65·0	69	·548			
„ 24th ...	7-16 A.M.	Ditto ...	...	23·69	67·5	61·5	72	·479	·889	·59	
„ „ ...	2-40 P.M.	Ditto ...	...	23·69	72·2	65·6	71	·563			
„ 25th ...	7 A.M. ...	Ditto ...	...	23·67	67·0	63·7	84	·567	·906	·63	
„ „ ...	7-30 P.M.	Rájpur ...	3,000	26·50	80·8	71·7	64	·672	·906	·74	
„ 26th ...	7-20 A.M.	Ditto ...	...	26·63	79·1	74·9	82	·813			

Psychrometric Observations in the Himálayas, 1881—concld.

Date.	Hour.	Place	Elevation above the Sea.	Barometer.	Dry Bulb.	Wet Bulb.	Relative Humidity.	Vapour tension.	Tension at Sea level	Ratio.	Weather Remarks
June 26th ...	10-30 A.M.	Rájpur	3,000	26·66	81·4	76·4	79	·857	·984	·82	
„ „ ...	12-30 P.M.	Ditto	...	26·66	78·3	73·0	78	·757			Rain.
„ „ ...	1 P.M.	Dehra	2,230	27·43	85·9	76·4	64	·800	·984	·81	
„ „ ..	2-25 P.M.	Mohan Pass ...	2,610	27·03	83·9	78·2	77	·885	·984	·90	Heavy rain.
„ „ ...	3 P.M. ...	Newára ...	1,720	27·73	86·4	79·5	73	·926	·985	·91	
„ „ .	3-25 P.M.	Mohan Chauki	1,480	27·92	91·9	79·7	57	·818	·984	·86	
„ „ ..	5-30 P.M.	Fatehpur . . .	980	28·43	93·7	79·7	53	·833	·984	·84	

Comparative observations of the Psychrometer and condensing Hygrometer.

Date	Hour.	Place.	Barometer.	Dry Bulb.	Wet Bulb.	Relative Humidity.	Computed Vapour tension.	Dew point calculated.	Dew point observed.
1881.									
May 1st ..	10-30 A.M. ...	Naini Tal .	23·70	73·3	56·0	32	·267	41·9	41·5
„ 4th	11 A.M.	Ranikhet Observatory ..	24·10	70·5	51·8	22	·165	29·8	26·2*
„ 17th ..	3-40 P.M. . .	Badrinath ...	20·59	59·2	49·7	55	·271	42·3	41·8
„ 19th ...	1 P.M. ...	Ditto ...	20·61	58·5	46·1	41	·200	34·5	35·8†
„ 29th	11 A.M. ...	Dobri ..	22·45	68·5	58·6	56	·395	52·4	51·4

* The light was bad and it was difficult to note the instant at which dew was deposited.
† Strong wind blowing

INDEX

OF

SUBJECTS IN VOL. I

OF THE

INDIAN METEOROLOGICAL MEMOIRS.

Govt. Central Press.—No. 38 Meteo.—17-10-81.—600.